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# TWENTY-FIRST ANNUAL REPORT

OF THE

**Regents of the University of the State of New-York,**

ON THE CONDITION OF THE

STATE CABINET OF NATURAL HISTORY,

AND THE

HISTORICAL AND ANTIQUARIAN COLLECTION ANNEXED THERETO.

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TRANSMITTED TO THE LEGISLATURE APRIL 20, 1868.

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1871.



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# State of New York.

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No. 92.

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## IN SENATE,

April 20, 1868.

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### TWENTY-FIRST ANNUAL REPORT

OF THE REGENTS OF THE UNIVERSITY ON THE CONDITION  
OF THE STATE CABINET OF NATURAL HISTORY, AND  
THE HISTORICAL AND ANTIQUARIAN COLLECTION AN-  
NEXED THERETO.

UNIVERSITY OF THE STATE OF NEW YORK:

OFFICE OF THE REGENTS, {  
ALBANY, *April 20, 1868.* }

To the Hon. STEWART L. WOODFORD,

*President of the Senate:*

Sir—I have the honor to transmit the Twenty-first Annual Report of the Regents of the University on the condition of the State Cabinet of Natural History, and the Historical and Antiquarian Collection annexed thereto.

I remain, very respectfully,

Your obedient servant,

JOHN V. L. PRUYN,

*Chancellor of the University.*

# REGENTS OF THE UNIVERSITY.

(*Ex-officio* Trustees of the State Cabinet of Natural History.)

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JOHN V. L. PRUYN, LL. D., *Chancellor.*

GULIAN C. VERPLANCK, LL. D., *Vice-Chancellor.*

## EX-OFFICIO.

REUBEN E. FENTON, *Governor.*

STEWART L. WOODFORD, *Lieutenant-Governor.*

HOMER A. NELSON, *Secretary of State.*

ABRAM B. WEAVER, *Superintendent of Public Instruction.*

ERASTUS CORNING.

ISAAC PARKS, D. D.

PROSPER M. WETMORE.

LORENZO BURROWS.

GIDEON HAWLEY, LL. D.

ROBERT S. HALE.

ROBERT CAMPBELL.

ELIAS W. LEAVENWORTH.

SAMUEL LUCKEY, D. D.

J. CARSON BREVOORT.

ROBERT G. RANKIN.

GEORGE R. PERKINS, LL. D.

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ALEXANDER S. JOHNSON, LL. D.

GEORGE W. CLINTON, LL. D.

GEORGE W. CURTIS, LL. D.

WILLIAM H. GOODWIN, D. D.

SAMUEL B. WOOLWORTH, LL. D. *Secretary.*

DANIEL J. PRATT, *Assistant Secretary.*

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## STANDING COMMITTEE OF THE REGENTS,

Specially charged with the care of the State Cabinet.

1868.

(The Governor), Mr. FENTON.

Mr. CORNING.

Mr. BREVOORT.

Mr. BURROWS.

Mr. CLINTON.

Mr. JOHNSON.

Mr. CAMPBELL.

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CURATOR OF THE STATE CABINET:

JAMES HALL, LL. D.

# REPORT.

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*To the Honorable the Legislature of the State of New York:*

The Regents of the University, as trustees of the State Cabinet of Natural History, respectfully submit this their

## TWENTY-FIRST ANNUAL REPORT.

For a detailed statement of the work done in the State Cabinet during the year 1867, and of the more important additions secured by purchase or otherwise, the Regents respectfully refer to the accompanying report of the Curator, and to the full list of additions prepared by him, marked (A) and (B) in the appendix to this report.

The Curator has also communicated a paper entitled "Notes and Observations upon the Cohoes Mastodon," which was stated in the last annual report to be in course of preparation.

The Botany of the State constituted an important part of the original "Geological Survey." A collection of indigenous plants was made under the direction of the Botanist of the Survey, Dr. Torrey, and constituted the "State Herbarium." It was mentioned in the Eighteenth Report that this Herbarium had been arranged in cases more convenient for reference, examination, and preservation than the portfolios in which it was originally placed. The work of perfecting this collection and putting it in the best condition has been entrusted to Mr. Charles H. Peck, an enthusiastic and accomplished botanist of this city. The Regents earnest-



ly recommend that an appropriation be made by which his services in this department may be permanently secured until this work is completed.

The standing committee of the Regents specially charged with the care of the State Cabinet, have bestowed much time and attention upon the alterations and improvements necessary to provide for the recent additions to the Cabinet, and upon the consideration of measures for its future care and improvement. While no lavish expenditures should be allowed, it is important that the State collections be properly cared for, and that they be, from time to time, increased to such a degree that they may be referred to as indices of the progress made in the special departments of natural science here represented.

The usual statement of receipts and expenditures is herewith communicated.

All of which is respectfully submitted,

In behalf of the Regents,

JOHN V. L. PRUYN,

*Chancellor of the University.*

ALBANY, *April* 20, 1868.

## ACCOUNT CURRENT,

With Appropriation for the State Cabinet of Natural History.

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### 1866-7. Dr.

To balance from 1865-6.....	\$2,671 60	
To appropriation for 1866-7.....	800 00	
	<hr/>	\$3,471 60
		<hr/> <hr/>

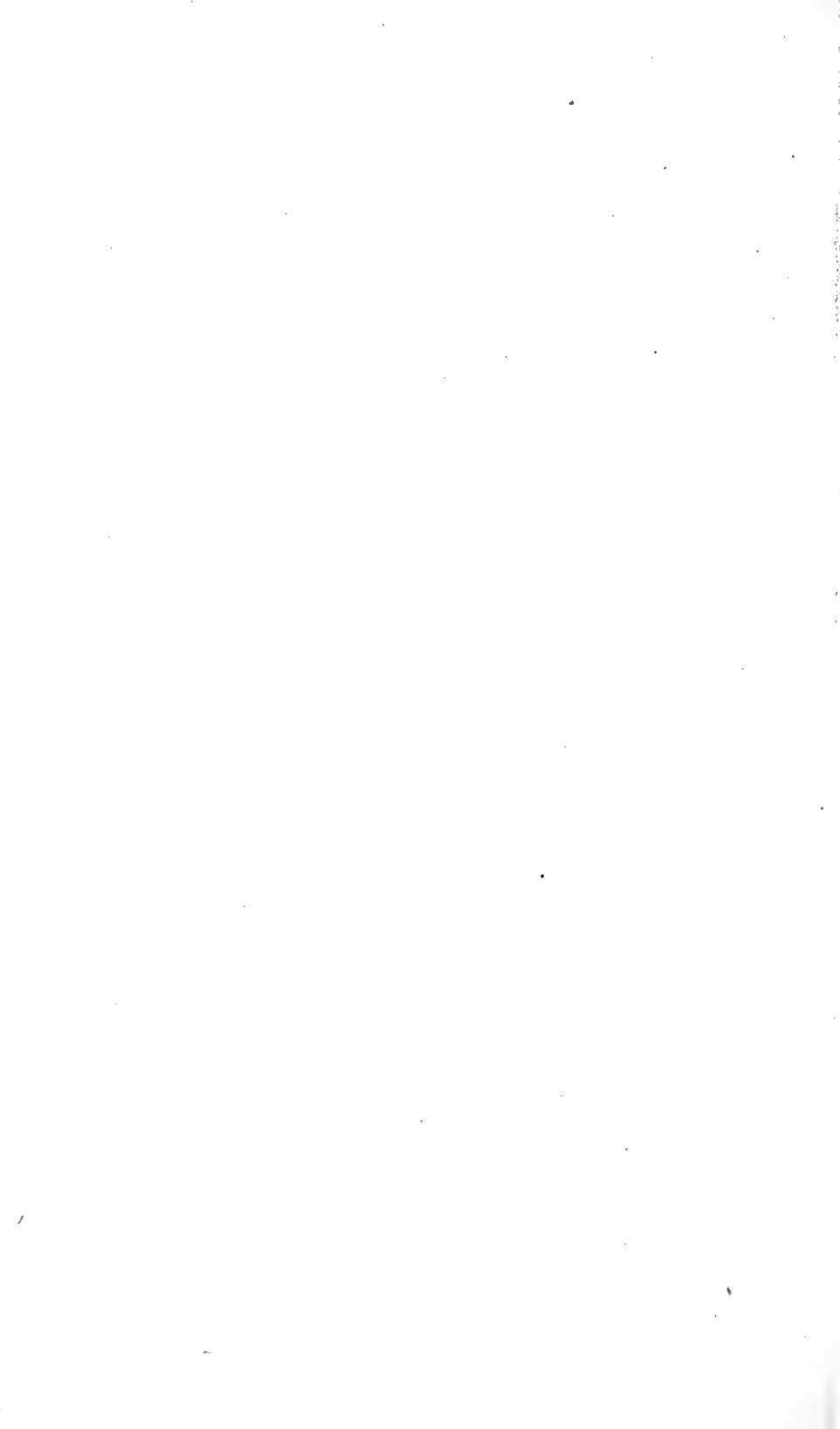
### Cr.

By collections.....	\$500 00	
By excavations for mastodon.....	377 59	
By chemicals .....	149 56	
By postage and stationery .....	101 67	
By shelving and cases.....	377 82	
By expressage and freight .....	50 40	
By cataloguing and labeling .....	706 86	
By traveling expenses of Curator.....	74 75	
By contingents.....	47 00	
By balance to new account.....	1,085 95	
	<hr/>	\$3,471 60
		<hr/> <hr/>

I have examined this account with the vouchers in support thereof, and find the same correct.

ALEXANDER S. JOHNSON.

ALBANY, *March* 14, 1868.



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# APPENDIX.

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(A.)

## REPORT OF THE CURATOR.

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*To the Board of Regents of the University of the State of New York:*

GENTLEMEN—I have the honor to present to you, the following communication regarding the State Cabinet of Natural History, with a statement of work done in the museum and in connexion therewith, together with the additions which have been made to the collections in the several departments since my last annual report.

The first weeks of the year were devoted to the preservation and arrangement of the bones of the Cohoes Mastodon, presented to the museum by Mr. Alfred Wild, in the name of the Harmony Mills Company; and some time was given to the superintendence of the work of excavation for other bones belonging to the same animal. After the work at the original point was abandoned, on account of the freezing of the water, some excavations upon the southwest side of the Mill revealed the presence of bones, which proved to belong to the same skeleton, and on the 26th of February and 7th of March, we obtained at this locality, nearly all the bones of the right fore-leg below the humerus. In the same place, we also obtained two bones belonging to the right hind-foot. The position in which these bones were discovered, was at least sixty feet distant from the point where the skull and principal parts of the skeleton were found, and at a level twenty-five feet higher. The bones thus obtained were of great use in the final work of mounting the skeleton.

In the general work of the museum I have commenced, and to  
[Senate No. 92.]

a considerable extent, completed a re-arrangement of the New York Geological Collection, on the second floor of the building, bringing into the series the collections of the Laurentian formation and Quebec group, which had been previously placed upon the same floor with the Mineralogical Collection. I have also restored the original arrangement of a geological series of the rocks of New York, in the new table cases which extend around the room, next to the wall cases. In this series I have replaced, to a great extent, the *original specimens* thus arranged by the State Geologists, as typical of the rock formations described by them. Farther examination of the collections in the wall cases, and the cases of drawers in the curator's room, will enable me to complete this arrangement the present year. The labeling of this part of the collection will soon be commenced.

The labeling of the Palæontological Collection of the New York Rocks, has progressed nearly as far as we have labels printed for it. Other duties have prevented me from attending to the continuation of the printing, which will soon be resumed.

In the early part of the summer, I was directed by the Capitol Commissioners to make an examination of all quarries from which specimens had been sent to the Commissioners, and also of other quarries which might afford material for the building of the new Capitol. Under these directions I have made extended examinations of stone quarries, both within and beyond the limits of the State. One immediate result of this work has been the great increase of the Economic Collections of the museum, and you now have at the Geological Rooms, a larger number of blocks of building stone, and, in greater variety, than can be found in any museum in the United States. This great accession to the Economic Collection, renders this department of the museum no longer an experiment, and the owners of stone quarries are desirous of having their material displayed in the collection. The recent direction to occupy both sides of the main entrance hall with these blocks, will afford facilities for the display of all we at present possess.

In addition to these collections of large blocks, other and extensive collections of smaller specimens of the same and other rocks have been made and placed in the Geological Rooms, but for want of space cannot be arranged in cases. The iron ores have likewise received some attention, and we have a considerable accession to the collections reported last year.

## MOUNTING OF THE MASTODON SKELETON.

After some delay, occasioned by the want of proper working rooms, the preparations for mounting the mastodon skeleton were begun in the latter part of June. In this work I engaged Mr. G. K. Gilbert, of Rochester, who was assisted by Mr. E. E. Howell and Mr. J. W. Hall.

The incompleteness of the Cohoes skeleton rendered it necessary that some comparisons of parts should be made with a more perfect skeleton, and accordingly, after carefully making a list of the bones we possessed, with measurements of the more important ones, the young men were sent to Boston, where they made the necessary examinations, and also made plaster casts of some bones to aid in their future work.

Acknowledgments are due to Dr. J. C. Warren for the liberal manner in which he gave the young gentlemen access to the Warren Museum for the study of the mastodon skeleton, as well as other separated bones of the mastodon, which was of great importance in the preparation of the work. Mr. Theodore Lyman also aided their objects in many ways. An examination was also made of the Cambridge mastodon skeleton; and our thanks are due to Prof. Wyman and Prof. Agassiz for facilities afforded for this and other examinations. Owing to this necessary preparation, the work of mounting the mastodon was not fully begun till the middle of July, and was continued without interruption to September. At this time the bed of the Mohawk below the Cohoes Falls became dry for the first time during the season, and I undertook to continue and complete some observations and surveys which preliminary examinations had shown to be necessary to give us a true knowledge of the position of the mastodon skeleton and its relations to the surrounding geology. Owing, therefore, to the occupation in this work for several weeks, the progress in mounting the skeleton was delayed. The results of the investigations are in part presented in a large, unfinished map, which I herewith communicate, and of which a reduced copy is presented in this report.

In making these surveys, we were much indebted to the Principal and Professors of the Rensselaer Polytechnic Institute, who granted the use of instruments and gave leave of absence to several young men who volunteered their services in the work of the survey. To Prof. Mason, of the Albany Academy, we were also indebted for the use of a theodolite.

The work of the survey is too incomplete to allow of the generalizations which we hoped to deduce from it; but it seems pretty clear that the pot holes in which the mastodon skeleton was found, were not made by the present or any former river in the same channel, but by some force which operated in a direction from north to south, and, as seems to us from present knowledge, to be connected with the great glacial movement. It is scarcely necessary to go into a detailed description of the map in its incomplete condition. In order to realize its intended objects, the survey should be continued from the mouth of the Mohawk to a point several miles above, and even to Little Falls, and also to the northward, before we can give such generalizations as the subject demands.

In the progress of the work of mounting the skeleton, a complete memorandum has been kept of all the bones preserved and their places in the skeleton, and also of all the missing bones for which substitutes have been supplied in plaster of paris. I might remark, also, that for all the important missing bones we have had the corresponding bones of the opposite side. This is true of one scapula, one half of the pelvis, the bones of the fore and hind legs, ribs, etc.; while the vertebræ have been modelled from measurements of the adjacent ones and from the corresponding members of the Warren mastodon.

The mastodon skeleton measures as follows :

	Feet.
Length of head and tusks.....	5 $\frac{1}{2}$
Spinal column.....	15
Total length following the curve.....	20 $\frac{1}{2}$
Total length in a direct line.....	14 $\frac{1}{4}$
Height .....	9 $\frac{1}{4}$

The skeleton as now mounted at the Geological Rooms stands about fifteen inches lower than it would have done had we adopted the ordinary mode of mounting. This is due mainly to bringing down the vertebral column and placing the scapulæ higher upon the side—a position which I think is the true one; while in the Warren mastodon and others, the bases of the scapulæ are placed nearly on a line with the sternal bones, which gives the greater elevation, but, as I believe, by a distortion of the relations of the parts. It was only after several trials and the careful consideration of the structure of elephants and other animals that the present position was adopted. However gratifying it might have been to be able to announce the skeleton as having a height of ten

and a half feet, this could only have been attained by an unnatural arrangement of the parts.

The skeleton of the Cohoes mastodon is now one of the most interesting and attractive features of the museum, and since its opening to the public on the 23d of December, it has been visited by several thousand persons.

In addition to the mounting of the skeleton, the surveys, etc., there have been made six casts of the lower jaw, which, from the peculiarity of the dentition, will be an object of interest for exchange with other museums. These have been carefully painted to imitate the color and expression of the natural one.

The accessions to the museum during the past year have been very large.

The recommendation of the Regents at their last annual meeting, that the Legislature appropriate money to purchase the Gould Collection of shells, was very promptly responded to by that body, and in February the sum of \$6,000 was appropriated to this object, and the agreement for the purchase at once concluded. The collection was delivered at the Geological Rooms in April and the money paid to the administratrix of Dr. Gould's estate.

#### THE KELLOGG COLLECTION OF CRINOIDEA.

In April last, the Regents purchased of Dr. J. M. Kellogg, for the sum of eight hundred dollars, a large collection of Crinoidea from rocks of the age of the Lower Carboniferous formations. This collection remains in drawers (properly indicated), beneath the geological table cases, on the second floor of the building. For the proper display of this collection, we need at least one table case of twelve feet long by two feet and a half wide—equal to one of those now occupied by the fossils of New York—still leaving many duplicates in the drawers.

During the autumn, the committee on the State Cabinet authorized the making of a collection of Crinoidea and other fossils from Crawfordsville, Indiana. The collection thus made is an extensive one, filling thirteen boxes, more than half of which are of crinoidal remains. Among the remainder are some very fine Bryozoans; Brachiopoda of the genera *Spirifera*, *Streptorhynchus*, *Productus* and *Lingula*; Lamellibranchiata of several genera; Gastropoda of the genus *Platyceras*; some Cephalopoda and Ptero-

poda; of Crustacea there are a few trilobites in a fragmentary condition. The Crinoidea are chiefly of the genera *Actinocrinus*, *Platycrinus*, *Cyathocrinus*, *Poteriocrinus*, *Scaphiocrinus*, *Forbesiocrinus* and *Trematocrinus* (*Gilbertsocrinus*). There are several impressions of star-fishes, one of a new genus, and also an echinoderm of a new form. These observations are made from the partial opening of a few of the boxes. This collection will require considerable labor to put it in proper order, and, when completed a proper selection from it will require at least an area of sixty square feet under glass, leaving many duplicates for exchange.

#### TAYLOR AND PICKETT COLLECTIONS.

During the summer my attention was called to two collections of fossils which were offered for sale,—one of these, the collection of Mr. G. W. Taylor, of Pulaski, and the other the collection of the late Prof. Pickett, of Rochester. Finding it impossible without neglecting other imperative duties, to visit these places personally, I sent Mr. Whitfield to examine the collections and report to me the contents. The general schedule of fossils in the collection of Mr. Taylor, offered but a moderate addition in number of species to the collections already in the museum, except in the *Orthoceratites*, of which he had a very fine variety and in considerable numbers; such, indeed, as it would be difficult to obtain without great labor and expense. Since the entire collection was valued at \$5,000, and Mr. Taylor declined to part with any portion without disposing of the whole, I could not recommend the purchase at that price.

The descriptive schedule of the Pickett collection (B *a*) which I append, showed that it contained rare and valuable specimens, which would be an acquisition to the museum, and as there was an offer pending from another quarter, there was no time for delay, and I wrote immediately in order to secure the collection. I have had it carefully packed and sent to Albany, where it has been placed in the Geological Rooms awaiting the action of the Regents.

#### MINOR ADDITIONS TO THE MUSEUM.

The Regents have likewise purchased a small collection of specimens, including a group consisting of calcareous spar, quartz crystals and a black indurated bitumen, which has been designated anthracite. The group is from a geode in the Calciferous

sandstone at Middleville, Herkimer county, N. Y. Such specimens are extremely rare, and its chief interest is from the fact, that pieces of the carbonaceous matter are included in the quartz crystals, showing its presence in this condition in the menstruum from which the quartz was crystallized, while both quartz crystals and lumps of the carbonaceous matter are embraced in the crystallized calcareous spar. These specimens will be arranged with the Mineralogical Collection.

In order to make a representation of the class Zoophyta, in the museum, the Curator has procured, by exchange, about twenty-five species of recent Corals. These specimens, together with what we may hope to add from time to time, will give a tolerable exhibition of this class.

A considerable number of rock specimens of various formations, some fossils, plants, shells and crinoidea, of the Chemung Group, have been added by the Curator; also some glacial-marked surfaces of the Chemung Group at Ithaca, and from the Hamilton Group at Malden, New York.

I might mention that among the minor duties and occupations of the Curator, is that of giving information upon specimens brought in, which are supposed to be valuable minerals. In far the greater number of instances the specimens are iron pyrites. This information is given verbally, in many cases, but of those sent in, or left during absence, the information has been given by letter, of which many have been written during the past year.

I have before reported the large number of shells packed in drawers and for which there are no cases. With the best arrangement that can be made, we cannot display under glass more than one-third of the Gould Collection, and by the time this arrangement is completed, we shall have more than twice as many shells in drawers as will be displayed in the cases.

A valuable package of Ethnological objects and implements from the Polynesian Islands, sent to the museum by the Smithsonian Institution, cannot be displayed for the want of space (of which there is not a single foot) in the proper part of the museum. Some other collections of similar character from New York remain packed in boxes.



In closing this report, I must most earnestly call the attention of the Regents to the absolute and immediate need of cases for the collections. The authority given to occupy the east side of the entrance hall and to raise the Wadsworth Gallery of Casts to the floor above will relieve the want partially; but this will scarcely afford any room to display the collections of the past year, except those belonging to the Economic Department. The whole of the space on the second floor thus vacated is no more than is required for the arrangement of the fossils of the New York rocks. Every available space is now being made use of. The two gallery openings will be closed up and still we shall not have room for our increasing collections. In this respect, we are doing that which is the legitimate object of a museum of natural history, for there is no one of these institutions in the civilized world which is not extending its accommodations to meet the rapidly accumulating results of scientific research, and at this moment the trustees of the Museum of Comparative Zoology at Cambridge have under consideration the plans and estimates for extending their building so as to equal four times its present capacity. It should be just cause for congratulation that more room is demanded for our rapidly increasing collections.

In our own case, the rooms at present occupied, have become entirely inadequate for the pressing wants of the museum, and making allowance for a moderate increase annually, we shall need twice as much space as we now have by the time a new building can be provided.

I am, very respectfully,

Your obedient servant,

JAMES HALL.

ALBANY, *January* 9, 1868.

(B.)

ADDITIONS TO THE MUSEUM DURING THE  
YEAR 1867.

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*I. BY PURCHASE.*

The Gould Collection of Shells, containing 60,000 specimens.

The Kellogg Collection of Crinoidea, containing about 1,000 specimens.

A small collection of Quartz Crystals, indurated Bitumen, Calcareous Spar, etc.

The Pickett Collection. (Schedule appended marked B a.)

*II. BY COLLECTION IN THE FIELD.*

A large collection of Crinoidea and other fossils from Crawfordsville, Ind.

Fossils from the Chemung Group.

Glacial-marked Slates.

A large collection of various rock specimens.

A collection of Potsdam Sandstone fossils from Keeseville, N. Y.

*III. BY DONATIONS TO THE MUSEUM.*

*I. To the Antiquarian and Ethnological Department.*

From Mr. WILLIAM FOORD, of Albany, N. Y.

An Indian implement (a leather rubber) found near Ten Eyck's farm in Bethlehem, Albany county, N. Y.

A Chinese razor.

From Hon. W. P. WATSON, of Port Kent, N. Y.

A Bullet raised from the magazine of one of Arnold's vessels burned and beached at Panton, Vt., after the naval battle with Carleton, 1776.

From the SMITHSONIAN INSTITUTION.

A collection of Ethnological objects from Polynesia.

From S. B. CHAMPION, Bloomville, Delaware county, N. Y.

A Stone Pestle of aboriginal manufacture, found near Bloomville, Delaware county, N. Y.

## II. *To the Botanical Department.*

From F. E. CHURCH, the Landscape Painter.

(Through Mr. E. D. PALMER, of Albany.)

A piece of a large Bamboo, six feet long and five inches in diameter. Brought by Mr. Church from South America.

## III. *To the Zoölogical Department.*

From C. L. STEWARD, Engineer on — R. R.?

A large piece of wood perforated by some species of Borer.

From HENRY E. LEGG, of Albany, N. Y.

A specimen of the River Gar, or Banded Gar, from the Hudson river.

From —, Albany.

Specimen of *Sphinx drupiferarum* Sm. Abb.

From G. W. HATTON, of Congress Hall, Albany.

A specimen of *Tropæa Luna* (Linn.)

Collections made by the MUSEUM.

Several species of Snakes collected at Crawfordsville, Indiana, by Mr. C. Vandelloo.

From Hon. L. H. MORGAN, of Rochester, N. Y.

Six specimens of Beaver Skulls, from the region of Lake Superior.

From Major WILLIAM TAYLOR, of St. Catharine's, C. W., formerly of the Hon. East India Company's service.

(Communicated by Mr. THEODORE KERNER.)

Skins of Serpents from the East Indies, of the following species: Cobra de Capello, two specimens; Cobra de Manilla, one specimen; Whip Snake, one specimen; Carpet Snake, two specimens; Boa (sp.?), one specimen. In all seven species.\*

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\* These species were erroneously credited in the Fourteenth Report as the gift of Mr. Kerner, and the correction is made at the request of Major Taylor.

IV. *To the Geological, Mineralogical and Palæontological Departments.*

From Mr. WILLIAM FOORD, of Albany, N. Y.

A large Shark's Tooth, from the London clay, London, England.

From Senor ASTA BRUMAGA, late Chilian Minister to the United States.

(Communicated by Hon. Mrs. J. V. L. PRUYN.)

Two specimens of Copper Ore from Chili.

From Dr. R. L. ALLEN, of Saratoga, N. Y.

A large slab, five by six feet, of Potsdam Sandstone, with one side showing fine ripple marks.

A large mass of Conglomerate, from the base of the Potsdam Sandstone in Greenfield, Saratoga county, N. Y.

A large slab of Lower Trenton Limestone, nearly five by six feet, with one side covered with hemispherical masses of *Stromatopora*.

These specimens are very valuable acquisitions for geological study, and, as a part of the out-door Museum, are placed in the area upon Lodge street.

From ALFRED WILD, of Albany, N. Y.

A mass of Iron Pyrites in shale from Cohoes (the pyrites massive and in minute crystals).

From Hon. EZRA CORNELL, of Ithaca, N. Y.

A block of nearly a cubic foot of Argillaceous Sandstone, dressed on three sides and partly on two others, showing the style of blocks used in the building of the Cornell University; one face covered with fossils.

A block of 9×9×11 inches of White Medina Sandstone; the same as used in the Cornell University.

From Mr. POTTER, of Fort Ann.

Several large masses of Magnetic Iron Ore, from the Port Dunk Mine, near Fort Ann, N. Y.

From LEWIS H. ROE, of Westport, Essex County, N. Y.

A large mass (300 pounds) of Magnetic Iron Ore, from mine near Comstock's Landing, Washington County, N. Y.

From B. F. OTTARSON, of Granville, Washington county, N. Y.

(Through W. H. WHITTLESEY, of Lakeville, Ct.)

Several good specimens of Hematitic Iron Ore, from Salisbury, Ct.

From C. E. BENEDICT, of Saratoga Springs, N. Y.

A miscellaneous collection, containing Rose Quartz, Felspar, Mica, Schorl, etc., from Greenfield, Saratoga county, N. Y.

From R. S. KENYON, Division Superintendent Merchants' Union Express, Albany, N. Y.

Calcareous Tufa (erroneously petrified wood), several specimens, collected between Fort Plain and Cooperstown, N. Y.

From Rev. J. E. BAKER, of Rochester, N. Y.

Two specimens of Slate with Stellate Fucoids or Graptolites, from the Roofing Slate quarries of Middle Granville, Washington county, N. Y.

From Ira A. GILCHRIST, of Salina, N. Y.

Part of a fossil Elephant's Tooth, from the gravel of Salina.

The section showed a depth of fifteen feet above the point where two elephant's teeth are said to have been taken out.

From PAUL F. COOPER, of Albany, N. Y.

A pebble of Argillaceous Sandstone of the Hamilton Group, showing spheroidal desquamation: Otsego county, N. Y.

From Col. JOHN M. WILSON, U. S. A., Albany, N. Y.

A specimen of Graywacke — Argillaceous Sandstone — showing decomposition to equal depths from the surface, owing to the presence of iron pyrites: New Baltimore, N. Y.

From HORACE DOUGLASS, M. D., Gloversville, N. Y.

A miscellaneous collection of specimens, Iron Ore, Pyrites, etc., for examination.

From S. B. CHAMPION, BLOOMVILLE, Delaware county, N. Y.

Specimens of Rock from Kortright Hills, Delaware county.

A specimen of Red Shaly Sandstone, and a decomposing ferruginous Sandstone, with *Spirifera disjuncta*.

From RENSSELAER DAY, of Otsego, N. Y.

Specimens of Stratified Clay, with ferruginous sandy layers.

From W. R. WHITTLESEY, of Lakeville, Ct.

A large mass of Iron Ore Hematite, enclosing imbedded masses of quartz, etc.

The Curator, when at the iron mines of Salisbury, Ct., received very fine specimens for the Cabinet from Mr. Alexander Hubbard, Mr. Peter P. Everts and Mr. John Dauchy.

From EDWARD LEARNED, of Pittsfield, Mass.

A mass of Sulphuret of Lead and Silver, from Colorado, weighing 42 pounds.

From S. FITCH, of Hudson, N. Y., formerly of Delhi, Del. Co. N. Y.

A slab of Red Shaly Sandstone, with the impression of a fossil fish (*Cephalaspis*) two feet in length, upon its surface.

The specimen is interesting, as showing for the first in the country, it is believed, this fossil fish in any other condition than separated scales and bones.

From THOMAS HOXIE, Leonardsville, Madison county, N. Y.

A slab of Argillaceous Sandstone with Worm-tracks.

BUILDING STONES PLACED IN THE STATE CABINET, WHICH HAVE BEEN OBTAINED THROUGH THE ACTION OF THE CAPITOL COMMISSIONERS.

Most of these have been obtained from the personal application of the Curator to the owners of quarries, nearly all of whom have responded very readily to his request for specimens, and some of them in a very liberal manner.

#### GRANITES.

From Dr. R. L. ALLEN, of Saratoga Springs, N. Y.

A dressed block of Gneissoid Granite, one cubic foot; Saratoga, N. Y.

From the QUINCY RAILWAY GRANITE COMPANY.

A dressed block of dark Syenitic Granite of one cubic foot; Quincy, Mass.

A block of light-colored, fine-grained Granite of one cubic foot, from Concord, N. H.

From RUNELS & CLOUGH.

A dressed block of light-colored, fine-grained Granite of one cubic foot, from Fitzwilliams, N. H.

From ROGERS & Co.

A block (6×8×12) of light-colored Quincy Granite.

From I. P. HARRINGTON, Barre, Vt.

A dressed block of Grey, light-colored Granite of one cubic foot, from Barre, Vt.

From the DIX ISLAND GRANITE COMPANY.

A dressed block of Grey Granite, from Dix Island, Maine.

From the ROCKPORT GRANITE COMPANY.

A small, partly dressed block of Granite ; Rockport, Cape Ann, Mass.

From GEORGE WRIGHTSON, New York.

A block of coarse Grey Porphyritic Granite, one foot long by six inches wide and thick.

#### MARBLES—METAMORPHIC LIMESTONES.

From SHELDONS & SLASON.

(Through S. W. ROWELL, of Rutland, Vt.)

Five blocks of Marble of one cubic foot each, showing all the varieties of marble in the quarries at Rutland, Vt.

From the OTTER CREEK MARBLE COMPANY, of Sutherland Falls.

Four dressed blocks of Marble, showing variety of texture, color and mode of dressing.

Four blocks of Marble, two of them six-inch cubes, showing varieties of color and dressing.

From H. TUDOR BROWNELL, of Hartford, Ct.

Two dressed blocks of Marble of one cubic foot each, one a white and the other a colored variety, from Salisbury, Ct.

From the BERKSHIRE MARBLE COMPANY.

A fine block of dressed Marble of one cubic foot, showing variety of dressing, from Alford, Mass.

From MASTERTON & HALL, of Tuckahoe, Westchester county, N. Y.

Two dressed blocks of White Marble, one of a cubic foot and the other a six-inch cube ; the same marble so extensively used in New York for building purposes.

Two blocks of White Marble of about one cubic foot each, from from Hastings, N. Y.; brought in by the Curator.

#### LIMESTONES UNALTERED.

From — HUGHES, Syracuse, N. Y.

A dressed block of Onondaga Limestone of about 10×10×8 inches, showing variety of dressing and having one face polished.

From JAMES SHANAHAN, of Tribes Hill, N. Y.

Two blocks of Blue Trenton Limestone, one of a cubic foot, showing a variety of dressing, the other a ten-inch cube more roughly dressed.



From JOHN CRETZER, of Jacksonburgh, N. Y.

A block of Trenton Limestone of about  $10 \times 12 \times 6$  inches, rough dressed.

SANDSTONES OR FREESTONES.

From the CLOUGH STONE COMPANY, of Loraine county, Ohio.

Two large blocks of fine-dressed Grey Freestone, and one square shaft measuring twelve inches at the base and eleven inches inches at the top.

From B. CLOUGH, of Plato, Ohio.

A fine-dressed block of Bluish-Gray Freestone of one cubic foot, from Columbiana, Ohio.

From GEORGE WRIGHTSON, of New York.

A fine-dressed block of Brown Freestone of one cubic foot, with one face showing fracture, from Seneca Creek, Maryland; the block taken from the same quarries as that used in the construction of the Smithsonian Institution and other buildings in Washington, D. C.

From H. J. SICKLES, of Albion, N. Y.

A handsomely dressed block of Brown Freestone (Medina Sandstone), from Albion, N. Y.; block  $12 \times 10 \times 8$  inches.

(B a.)

SCHEDULE OF THE CONTENTS OF THE PICKETT COLLECTION,  
PURCHASED FOR THE MUSEUM.

1. The *Lower Silurian* fossils are represented in collections from Cincinnati, Ohio ; Pulaski and other places in New York.
2. The *Medina Sandstone* is represented by a few fossils only.
3. The *Clinton Group* is largely represented by the characteristic fossils which occur in New York.

4. The *Niagara Group* is largely represented. There are many fine Corals and Bryozoans, and of the latter some remarkably fine specimens, particularly of the genera *Callopora* and *Trematopora*.

There are several specimens of *Encalyptocrinus*, *Stephanocrinus*, etc., and a fine series of the Brachiopoda of that Group of rocks.

5. The *Lower Helderberg Group* is but feebly represented in collections from Albany and Schoharie counties.
6. The *Upper Helderberg Group* is mainly represented by Corals. Many of these have been worked out by acids, so as to be almost entirely free from adhering stone, leaving the silicified corals in fine condition.

There are also a few Brachiopoda and Lamellibranchiata, Cephalopoda, Bryozoa and Crustacea.

7. The *Hamilton Group* is largely represented by the fossils of Western New York in all the different classes. The most conspicuous and important of these are the Crinoidea, of which there are many fine specimens of several genera and species. Of *Actinocrinus eucharis* (of which but one specimen has been seen by me before) there are three or four. There are also specimens of *Megistocrinus*, *Cacabocrinus*, *Poteriocrinus*, and one new species of *Rhodocrinus* of remarkable character.
8. The *Chemung Group* is represented in a considerable number of fossils, a few crinoids, which are rare, and some fine slabs of *Filicites* (fossil ferns).
9. The *Burlington Limestone* is represented by a considerable number of Crinoidea of the ordinary character.

10. The *Keokuk Limestone* is represented in the Crinoidea of Crawfordsville, Indiana, of which there is a large box not opened. The specimens were represented by Mr. Pickett and by Mr. Elwood as consisting largely of crinoids collected by Prof. Pickett himself; judging from other parts of the collection made by him, it may be inferred that the specimens are good.

There are some representatives of the other divisions of the carboniferous rocks, and among them a collection of the Spurgeon Hill fossils.

11. The *Coal Measures* are represented in a good collection of fossils from the shales of Danville, Illinois.

There are also two large boxes which were not examined, but which were said to contain good cabinet specimens.

Besides those enumerated, there are many large slabs and polished blocks of different rocks, showing the condition of the corals, crinoids, etc.

A small collection of European Jurassic and Cretaceous fossils.

*Minerals.*—The Collection contains some minerals, mostly from Lockport, N. Y. and from New England.

*Fresh-water Shells.*—There is a considerable collection of Uniones, Anodons, etc., but mostly in a poor condition. Some of them will be useful.

*Radiata.*—There is a pretty large collection of Starfishes and other Echinoderms in a good condition. These had been obtained mostly from Prof. Agassiz in exchange for fossils. The specimens have labels with them and have been apparently carefully kept as they were received.

This part of the collection will supply a want in the Museum, since, as I have had occasion to state, we had previously but one or two Starfishes and one Echinus in the State Collection to represent this large class of organisms.

Mr. Pickett at first desired to stipulate that this collection should remain separate, as "*The Pickett Collection*," in the State Museum; but when the impracticability of such a plan was represented to him, he became willing to have it incorporated in the general collections of the Museum, provided that a catalogue of its contents should be published in some future report on the State Cabinet.—The collection was received in good order at the State Cabinet in November.



(C.)

## REPORT OF THE BOTANIST.

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DR. S. B. WOOLWORTH :

Sir—I herewith submit the following brief statement of work done toward completing and perfecting the *State Herbarium*.

Since July 1st, there have been added to the Herbarium, specimens of two hundred and eighty-two species, of which one hundred and thirty are Phænogamous or Flowering plants, and one hundred and fifty-two are Cryptogamous plants belonging to the orders Musci and Hepaticæ. Collections of Lichens and of Fungi have been commenced, but the specimens collected have not yet been critically examined. Probably about forty species of the former and eighty of the latter order are represented.

Of the one hundred and thirty specimens of Phænogamia, fifty-eight supply deficiencies published in the Regents' Circular of 1864, twelve supply deficiencies not published therein, and the remaining sixty are added because they represent some peculiar variety, or will aid in giving a more complete idea of the several species.

Of the one hundred and fifty-two Cryptogamia, one hundred and ten are Mosses and forty-two are Liverworts. A few of these have been obtained from correspondents or in exchange, but they are mostly of my own collecting.

Specimens of one hundred and twenty-one species of Phænogamous plants have been selected from the packages contributed by various botanists from time to time in response to the Circular of the Regents. Of these, seventy-seven supply deficiencies published therein; the remainder either supply unpublished deficiencies, or being beautiful specimens, are added for the better representation of species.

These, as well as my own additions of Phænogamia, have been laid upon sheets preparatory to mounting and poisoning, which work I have not yet had time to do.

Specimens of seventy-eight species of Mosses have been mounted. This work is now in progress.

Six species of Flowering plants and thirteen of Mosses and Liverworts, new\* to the State, have been detected by me. All except four of these were discovered in the Adirondack region. These, with other discoveries both by myself and others, are more fully noticed in a paper entitled "Facts and Observations touching the Flora of the State of New York."

A series of ninety-eight specimens of Algæ collected in Peconic Bay, Long Island, and comprising about twenty species, were presented to the State Cabinet by Mrs. M. A. Bush. These were undetermined. About half of them have been microscopically examined and identified. Others being without fruit cannot be satisfactorily determined until further collections are made.

CHARLES H. PECK.

ALBANY, *January 1, 1868.*

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\* That is, they are not contained in the official Reports of Dr. Torrey and Judge Clinton, nor in my list of Mosses in the Nineteenth Cabinet Report.

(D.)

## THE STONE AND BONE IMPLEMENTS OF THE ARICKAREES.

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By Hon. LEWIS H. MORGAN.

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*To the Honorable the Board of Regents of the University of the  
State of New York:*

Indian arts and inventions are the same over all the North American continent, with a higher development of the same conceptions in particular localities. The social condition of the Iroquois of New York can be illustrated with nearly as much certainty, by the implements and utensils of the Indian family at large, as by those of their own construction. Inasmuch as they have now passed, substantially, out of their aboriginal condition, we are compelled to look beyond our State limits to find many of the fabrics, implements, inventions and utensils which were in common use among them at the epoch of their discovery. Our State Collection, therefore, in order to illustrate fully the aboriginal period of our history, must draw from the Indian family at large, as well as directly from the Iroquois themselves. This obvious truth should be held constantly in view in the efforts made for its enlargement.

This Collection now contains about 3,000 specimens of implements of stone, illustrative of the so-called Stone Age of the American Indians. It may be well to state, by way of comparison, that the Copenhagen Museum contains 9,000 specimens of stone implements, while the several cabinets in Denmark, are estimated to contain, in the aggregate, 30,000; and that of the Museum of Stockholm 16,000. These memorials of the Stone Age of the

primitive inhabitants of Europe, are as highly valued as the collections in any other department of knowledge.\*

In the year 1862, I obtained at the old village of the Mandans on the Upper Missouri, a series of stone mauls, stone hammers and bone implements, of which I propose to give a brief description. They belong to the Stone Age of the American aborigines.

The village, at that time, was deserted of its inhabitants, and had been for several months; but many of the original houses were still standing, and some of them in as good condition as when abandoned. Fort Clarke was constructed in 1829, by the American Fur Company, by the side of this village, and this will determine its site upon the map.

The Arickarees were the last inhabitants of the village. These implements were left there by them; but since they might have been left by the Mandans to the Arickarees, as they were subsequently abandoned by the Arickarees to the first finder, a brief notice of both nations becomes necessary. It is immaterial to which they originally belonged, so long as it is made certain that they were used by one or the other.

Among the Stationary Village Indians, north of New Mexico, the Mandans have ever held a conspicuous position. They have been regarded as the introducers of agriculture upon the Upper Missouri, as well as the originators of the peculiar and distinctive timber-frame house, known as the Mandan lodge, which, I believe, has not been found, except amongst the nations which inhabited the banks of the Missouri and its western tributaries. There are some reasons, however, for supposing that the Minnitarees, and not the Mandans, were the inventors of this form of house, and also the introducers of cultivation into this region; but it is unnecessary, in this connection, to consider these questions. The Mandans belong to the Dakota stock, but find their nearest affiliation with the Lower Missouri nations, namely: the Pankas, Omahas, Iowas, Otoes, Missouris, Osages and Quappas. These last nations, in dialect, are nearer to each other, interchangeably, than either is to the Mandans; whence it follows that the separation was remote in point of time, but the Mandan dialect is nearer to this group of dialects than it is to the Sioux or Dakota proper.

In comparison with the nations east of the Mississippi, our

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\* The Smithsonian collection at Washington contains about 10,000 stone implements. It is the most complete collection, in the extent, variety and perfection of the specimens, in this country, and probably in the world.



knowledge of the Mandans is recent ; but, since it commenced, it has been unusually ample. The French Colonial records of Canada, which closed in 1764, and the English Colonial records of New York, which terminated in 1781, both of which embrace information concerning nearly all the Indian nations east of the Missouri, make no mention of the Mandans or Arickarees. Their position high up on this river, placed them beyond the reach of intercourse, even with the early traders and explorers, and their existence was unknown until about the year 1750. Lewis and Clarke, who wintered in this Mandan village in 1804-5, gave the first definite account of the two nations. " Within the recollection of living witnesses," they remark, writing at the Mandan village, " the Mandans were settled, forty years ago, in nine villages, the ruins of which we passed about eighty miles below, and situated seven on the west and two on the east side of the Missouri. The two, finding themselves wasting away before the small-pox and the Sioux, united into one village, and moved up the river opposite the Rickaras. The same causes reduced the remaining seven to five villages, till at length they emigrated in a body to the Rickara nation, where they formed themselves into two villages, and joined those of their countrymen who had gone before them. In their new residence they were still insecure, and at length the three villages ascended the Missouri to their present position, \* \* \* while the single village took a position on the southeast [east] side. In this situation they were found by those who visited them in 1796; since which time the two villages have united into one. They are now in two villages, one on the southeast [east] side of the Missouri, the other on the opposite side, and at the distance of three miles across. The first, in an open plain, containing about forty or fifty lodges, built in the same way as those of the Rickaras ; the second, the same number, and both may raise about three hundred and fifty men."\* This would give them, in 1804, a total of seventeen hundred and fifty souls.

In 1832, Prince Maximilian, of Neuwied, spent several months with the Mandans, at the same village where Lewis and Clarke found them ; and in his work† gives a full and interesting account of their manners and customs. Again, about 1834, George Catlin spent several weeks at this village, and devotes several chapters

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\* Travels to the Sources of the Missouri, &c., Longman's Lond. Ed., 1814, p. 96.

† Travels in North America.

of his work to the Mandans,\* with numerous engravings illustrative of their domestic life. No Indian nation has been portrayed in such a friendly manner, nor from an equally advantageous stand-point. It has tended to place them in striking contrast with contemporary Indian nations, whilst in point of fact, they should be regarded only as an excellent type of the more advanced class of village Indians. He estimated their number at two thousand souls.

Catlin's visit marks the close of their prosperity as a nation. In the summer of 1838 the small-pox was introduced among them from the steamer of the American Fur Company, unintentionally, no doubt, but under circumstances not exonerating them from censure. Nearly the whole nation perished before the ravages of the pestilence ceased. According to some accounts, thirty or forty only survived. Those who did escape, at once abandoned the village and occupied a small summer village two miles above, where they remained for a time, the length of which I have not been able to ascertain. They finally removed to the Minnitaree Village, near the site of Fort Berthold, about sixty-five miles further up the river, and on the northeast side, where I visited them in 1862. They then numbered about two hundred, and still preserved their nationality and separate government. In personal appearance they are superior to the Indians of the Missouri river, with the exception, perhaps, of the Blackfeet.

Their successors, in the old village, were the Arickarees; sometimes called Rickaras, Rickarees and Rees. They belong to the Pawnee stock, which at once separates them from all traceable connection by blood or dialect with the Dakotas, and all other Indian stocks east of the Missouri. Neither the Arickarees nor the Pawnees ever lived east of the Missouri river, as their traditions affirm, except in a temporary winter village constructed for nearness of access to game and fuel. In 1804 the Pawnees lived upon the Platte river and its tributaries, in three bands, known as the Grand Pawnees, the Republican Pawnees and the Wolf Pawnees, and were estimated by Lewis and Clark to number five thousand souls.† Besides these bands there was a fourth, which had been driven south by the Osages to the Canadian river, where they joined their kindred of the Pawnee stock. It is now understood that the Waccoes, or Huecos, the Wichitas, Keechies and Towaches of the Canadian and Red rivers belong to the Pawnee stock,

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\* North American Indians. Letters XI to XXII, V. I.

† Travels, p. 76.

one of which is the fourth band above named. Gregg was the first to point out the affiliation of these bands with the Pawnees,\* which Turner afterwards confirmed by a comparison of the vocables of their dialects.† Gregg calls the Pawnees the "Ishmaelites of the Prairies," whose hands are against every man and every man's against them.

The Arickarees are the only known remaining branch of the Pawnee stock, except those previously named. Since their discovery they have resided on the Upper Missouri, far removed from their congeners, and have lived in villages with houses constructed on the Mandan model, and depending chiefly upon agriculture for subsistence. At the time of Lewis and Clarke's visit they resided below the Mandans. "The three villages," they remark, "which we have just left are the residence of a nation called the Rickaras. They were originally colonists of the Pawnees, who established themselves on the Missouri, below the Cheyenne, where the traders still remember that twenty years ago they occupied a number of villages. From that situation the Rickaras emigrated to the neighborhood of the Mandans, with whom they were in alliance. The rest of the nation continued near the Cheyenne till the year 1797, in the course of which, distressed by their wars with the Sioux, they joined their countrymen near the Mandans. Soon after a new war arose with the Mandans, in consequence of which the former came down to their present position."‡ They estimated their numbers at six hundred and fifty men, which would give their total number at three thousand two hundred and fifty souls. At the time of Catlin's visit, about 1834, the Arickarees were probably near the mouth of Grand river, and, if so, a hundred miles below the place where Lewis and Clarke found them. He merely passed by their village, which he describes as follows: "The Rickaree village is beautifully situated on the west side of the river, two hundred miles below the Mandans', and built very much in the same manner, being constituted of one hundred and fifty earth covered lodges, which are in part surrounded by an imperfect and open barrier of piquets set firmly in the ground and ten or twelve feet in height. The village is built upon an open prairie, and the gracefully undulating hills that rise in the distance behind it are

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\* Commerce of the Prairies, II, 251, note.

† Explorations for a Railroad Route, etc., to the Pacific, III. Report on Indian Tribes, p. 64.

‡ Travels, p. 76.

everywhere covered with a verdant green turf, without a tree or a bush anywhere to be seen.”\* They were then probably living near the mouth of Grand river, although it is less than two hundred miles below the old Mandan village.

After the nearly total destruction of the Mandans in 1838, and the abandonment of their village, as before stated, the Arickarees moved up the river and occupied this village permanently until 1861, when the destruction of Fort Clarke by fire having deprived them of all protection against the Dakotas, their hereditary enemies, they, in turn, were forced to its abandonment. They moved up the river to a point two miles above the Minnitaree village, and on the opposite or southwest side of the river, where I found them in 1862 actively engaged in the construction of a new village. It is back on the bluff, about half a mile from the river. The Minnitarees urged them to settle on their side and make common cause with them against the Dakotas; but they refused, assigning as a reason that they, and their ancestors before them, had always lived on the west side of the great river, where they thought it more prudent for them to remain. The Arickarees are inferior to the Mandans physically, intellectually and morally; but practice many of the same religious ceremonies of “cord swinging,” “dragging the horns,” etc.

The remote affiliations of the Pawnee stock must be sought among the Indian nations of the Rocky Mountain range, and westward of this line, rather than in the central or upon the eastern side of the continent.

These brief sketches of the Mandans and Arickarees have been introduced to show, that down to the commencement of the present century, they had substantially been shut out from intercourse with our people, and were still practicing their primitive arts and ancient usages. Even down to 1829, although reached before that time by the traders, they were so remote and inaccessible, that trade had made little or no impression upon their mode of life. They were still using stone mauls, stone hammers, bone implements and pottery of their own manufacture, as is proven by the presence of these articles in their houses. The instances are rare, however, in which stone implements have been taken, as in the present case, so nearly direct from the hands of their original proprietors.

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\* North American Indians, I, 316.

The stone, bone and other implements and utensils, about to be described, I procured at the old Mandan village above named in the year 1862, and they are now in my collection.

#### IMPLEMENTS AND UTENSILS.

*Stone Maul.*—This specimen (Plate I, Fig. 1) is 8 inches long,  $5\frac{5}{8}$  inches broad and  $4\frac{7}{8}$  inches thick. It is oval, flattened and quite symmetrical in its proportions, and weighs  $12\frac{3}{4}$  pounds. The stone is a water-worn granite pebble. The groove, which is neatly and accurately cut, is an inch wide and a trifle less than a quarter of an inch deep. It is not carried entirely round the stone, but interrupted for the width of an inch at the centre of one side. This seems to have been left to save labor, and also to indicate the handle side of the stone. When mauls are perfect in form and unworn by actual use it will generally be found that the groove is above the centre, about three-fifths of the distance from the hammer face, or end, wherefore the narrow section not grooved shows at once which end was selected for the hammer face, and which for the handle side of the stone. The groove is designed for the adjustment of a withe handle in its cavity, as is well known, which, after passing around the stone, has its two parts united and wound with raw-hide to form a handle. As the withe leaves the stone on the handle side before its two parts come together, nothing would be gained by carrying the groove entirely round the stone. Its omission also shows, by necessary implication, that the work of grooving a piece of granite was slow and laborious in the Stone Age. Such a maul as this would be useful for driving stakes and posts, or other work where a heavy blow was required. The ancient miners for copper on Lake Superior used mauls of this kind for breaking off fragments of native copper from the mass. This implement has worn down but little on the hammer face; but it shows some use by a slight flattening of the lower end. It belongs to the class of stone implements distinguished as hammers; but its size and weight seem to render some distinction necessary between it and the common hammer. Among hammers it is, at least, a sledge-hammer. In Plate II, Fig. 1, A, the handle side of the maul is shown to exhibit the section not grooved.

*Stone Maul in Handle*—Plate I, Fig. 2.—This maul is a more interesting specimen than the first, because it is complete, just as it was used by the Arickarees. It is an oval stone, more flattened than the one last described,  $5\frac{3}{4}$  inches long, 5 inches broad in its

greatest width and nearly 3 inches thick. The groove is  $\frac{7}{8}$  of an inch wide and nearly  $\frac{1}{4}$  of an inch deep, and carried around the stone, with the exception of an inch or less on the handle side. It is a tough stone, apparently hornblende, and weighs  $6\frac{1}{4}$  pounds. The handle, which, including the portion fitted to the groove, is 18 inches long, is made of an ash sapling split in the centre and rounded on the inner side to fit and fill the groove. After passing round the stone the ends are brought together and bound from the extremity up to the stone, with a rawhide band, cut in a strip nearly an inch wide. As thus adjusted and secured, the stone is firmly held, and can be made to deliver a heavy blow without breaking the handle. The hammer face has apparently been worn up about  $2\frac{1}{2}$  inches by use. Such, at least, is the case if the stone was symmetrical originally. Stones of this kind do not chip or fracture under blows, but pulverize on the face, and thus wear down gradually. Those used for mauls and hammers appear to have been specially selected with reference to this quality. In Plate I, Fig. 2, A, the face of this hammer is shown.

*Stone Maul*.—Pl. I, Fig. 3.—This stone has been much worn by use. The groove is now below the centre. At least an inch and a half of the hammer face has been worn away, which is the best evidence, either of the long period of time during which it was used, or of the great amount of service it has been required to perform. The groove is not carried entirely around the stone, but there is a slight concavity on the handle side.

*Stone Hammer*.—The most interesting specimen in the series of stone implements, is the stone hammer, represented in Plate II, Fig. 4; since it exhibits an improved method of securing the handle. The stone is a granite pebble from the drift, as those previously described, in which felspar appears to predominate. In length, it is  $4\frac{1}{2}$  inches, breadth  $3\frac{1}{4}$  inches, and in thickness  $2\frac{1}{2}$  inches. With the handle, it weighs  $2\frac{3}{4}$  pounds, and is about the standard size and weight of a serviceable stone hammer. A withe handle sixteen inches long was first adjusted in the groove, and the ends secured by a rawhide string next to the stone. Over this a covering or case of buffalo rawhide was stretched and adjusted, consisting of a single piece. It was first fitted around the handle, commencing at the small end, and sewed up tight with thread of sinew, after which it was drawn closely around the stone, covering the whole of it, except the hammer face,

and about an inch and a quarter of the stone ; the seam being carried along the upper side of the handle, over the top of the stone, and down the side opposite the handle. Two-thirds and more of the stone were thus encased in a socket of rawhide, adjusted to it, without doubt, in a green state, and the handle itself included in the same covering. It was sewed with a single thread of sinew, and by means of a bone awl, the thread being passed through the skin from the under to the upper surface on each side, alternately, and the skin drawn to a close seam. Stretched and fitted around the stone in this manner, when the hide was soft, the drying and shrinking process would give to such a handle great strength. It is so firmly held and so strongly secured that a powerful man might put his entire strength into a blow, without dislocating the handle. For efficiency and convenience, it is a much more perfect instrument than we would suppose could be made of stone. The hammer face shows no signs of chipping, but the ordinary signs of reduction by the process of pulverization. In Fig. 4, A, Pl. II, the hammer face is shown.

*Stone Hammer*—Fig. 5, Pl. II.—This a fine-grained granite pebble, with quartz predominating, and worn unusually smooth. It is  $5\frac{3}{4}$  inches long,  $2\frac{5}{8}$  inches broad, and  $2\frac{1}{2}$  inches thick. The groove is interrupted for an inch on the handle side, and shallower than those previously described. That it had been used in a handle seems to be proved by the fact, that the hammer face is worn down, and also the opposite end. The stone, however, is inferior in quality for the purpose designed, as is shown by its chipping in two places on the hammer face. In Catlin's Work on the North American Indians (Phila. ed. 1857, 2, 463), there is an engraving of a group of several Indians, the person most conspicuous holding in his hand a weapon consisting of a stone like this in size and form, set in a withe handle. It was undoubtedly a war-axe, as he is represented in full costume ; and it serves to show that stones thus handled were used as weapons. Among our people a common name for a stone like this, when found grooved, is *skull-cracker*. The engraving does not indicate the nationality of the person, but from the text it is rendered probable that he was an Osage chief.

*Stone Hammer*—Fig. 6, Pl. III.—The stone is a granite pebble, of a reddish brown color, 5 inches long,  $3\frac{3}{4}$  inches broad, 3 inches thick, and quite symmetrical. It weighs three and a half pounds. The groove, as in the other cases, is interrupted on the handle side.

The stone is still within its handle of withe, adjusted and secured in the usual manner. About an inch of the hammer face has been worn down by use, and the superior quality of the stone, for a hammer, is shown by the smoothness of the hammer face, as worn by pulverization. It is a fine specimen. In Plate V, Fig. 6, A, the face is shown.

*Stone Hammer*—Fig. 7, Pl. III.—This implement shows more wear than any other in the series; it having literally been worn out on one end, and then turned and nearly worn up on the reverse end. It is a granite pebble. It is  $3\frac{1}{4}$  inches long,  $3\frac{5}{8}$  inches broad, 3 inches thick and weighs two pounds five ounces. Originally it must have been at least five and a half inches in length. The groove was evidently interrupted on the handle side, and afterwards completed by a slight grooving of the remaining space. It will also be noticed that the two hammer faces are not parallel, which divergence may have been produced by reversing the handle. The original hammer face was that nearest the groove; and the reverse end, which is blackened with charcoal, apparently by breaking up partially burnt fire-wood, was, probably, the one last used.

*Stone Hammer*—Fig. 8, Pl. III.—We have, in this specimen, a very smoothly worn granite pebble,  $4\frac{3}{4}$  inches long,  $3\frac{1}{4}$  inches broad,  $2\frac{1}{4}$  inches thick, and weighing two pounds. The groove is shallow and interrupted on the handle side, for the space of half an inch. It shows but little use, the hammer face being still convex, although worn down about a quarter of an inch; but a roughened and battered surface,  $1\frac{5}{8}$  inch by  $1\frac{1}{8}$  inch in diameter, shows distinctly its use as a hammer. In the figure the ends are reversed.

*Stone Hammer*—Fig. 9, Pl. III.—This hammer is noticeable for the great amount of service it has evidently performed. It is worn up nearly to the groove, on the original hammer face, and for nearly an inch on the reverse end. In another respect, it differs also from those previously described, in that the groove is carried, at equal depth, entirely round the stone. It is a granite pebble,  $3\frac{1}{4}$  inches in length,  $3\frac{1}{2}$  inches in breadth, and  $2\frac{1}{2}$  inches in thickness in its greatest dimensions. Originally it was at least five inches long, with the groove above the centre. As each end has been used alternately, as the hammer face, it seems probable, from the completion of the groove, that it has been re-handled upon the



opposite side. The handle, however, is so adjusted as to admit of a blow with either end, so that the only evidence of a change of side is the completion of the groove.

*Stone Crusher*—Fig. 10, Pl. III.—The form given to this implement is in part artificial. It is a nodule, apparently, of limestone. Upon the back side the hollowing out near the centre, is precisely as left by natural causes, whilst in front it has been ground out to correspond, probably by the use of sand and water. The evidence that it has been cut down by artificial means, is apparent upon the surface. It is 7 inches long,  $3\frac{1}{2}$  inches broad, and  $2\frac{3}{4}$  inches thick, in its greatest dimensions; and  $2\frac{1}{4}$  inches broad, and  $1\frac{1}{2}$  inch thick at the concavity. It was undoubtedly clasped in the hand and used to crush or pulverize hard substances in a mortar, or upon another stone. The stone is quite symmetrical in form, and the hammer face shows unmistakable marks of usage, with a small fragment chipped out on the back side. It is not equal in quality, as a stone implement, to those of granite. It appears from these specimens, that the nearer they are to a true granite, or with a slight preponderance in the proportion of felspar, the better will they bear usage. All of these described, except the last, were evidently pebbles from the drift.

*Stone Hammer*—Fig. 11, Pl. III.—This specimen concludes the series of stone implements. It is the smallest of them,  $4\frac{1}{2}$  inches long,  $1\frac{3}{4}$  inch broad, and  $1\frac{3}{8}$  thick, and is of granite with quartz predominating. The groove was exactly in the centre, and is interrupted on the handle side. It has one peculiarity; the narrow side opposite the handle has been ground down flat, for which reason this side is shown in the engraving. For what object it was done is not apparent. The inferior quality of the stone is shown by its chipping in several places on the hammer face.

The manner in which these grooves were cut, does not appear from the grooves themselves. In nearly all of them, the cut surface is so rough and so much pitted as to preclude the supposition that it was ground out with a rubber, by means of sand and water. The one last described is smooth enough to have been thus cut; but all the others appear to have been pecked with some harder substance. So far as any inference can be drawn from the grooves themselves, the work seems to have been done by the slow process of pecking.

Another interesting question remains with respect to the use of these mauls and hammers. They are of different sizes, weighing from one to twelve pounds, and, of course, adapted to different kinds of work. The mauls were evidently used where heavy blows were required, such as driving stakes and posts, and would be indispensable in constructing timber-framed lodges. They would also be useful for breaking up fire-wood. The hammers would serve a greater variety of purposes, such as breaking up the bones of the buffalo, the elk and the deer to obtain the marrow, breaking ribs and other small bones, preparatory to cooking; pounding dried meat; bruising wood to separate it into splits for basket work; bruising bark, to separate it into filaments, for making ropes and strings, and for many other similar uses suggested by the exigencies of their condition. The necessities which pressed them for such implements, were met by increasing the size and form of the hammer until it was made to subserve the purposes of many different implements in civilized life.

*Elk-Horn Skin Dresser*—Fig. 12, Pl. IV.—Bone implements, particularly needles or awls, were much used by the American Aborigines. Whether bone handles and sockets for axes, chisels and adzes, were used in any case, as they were by the inhabitants of the Swiss lake villages, I am unable to state. M. Troyon shows about thirty different forms in which axes, adzes and chisels were thus mounted,\* giving a remarkable variety of implements of this class. Aside from awls, needles and arrow-points, I know of no single implement of bone in universal use amongst the American Aborigines. The instrument shown in the figure is of elk horn, 12 inches long,  $1\frac{1}{2}$  inch in diameter, round, polished and nearly straight. The projecting blade measures three inches in length from the inside of the handle, and the blade is  $1\frac{1}{4}$  inch wide. It weighs one pound and one ounce. The smoothness of the bone shows that it has been much used. In forming the blade, the exterior surface, on both sides, was cut away, showing the brown and porous bone which forms the pith. It is, however, solid throughout. The color of the handle is a yellowish white. It was probably made after the Arickarees became possessed of metallic implements. At the time it was found at the village, Mrs. Culbertson, a native Blackfoot woman, informed the author

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\* Habitations Lacustres. Plates III and IV.

that it was used for dressing skins; that is, for scraping off the flesh and muscle that adhered to skins when first removed from animals. It seems to have been a substitute for the stone chisel, supposed to have been used as a flesher. In the Smithsonian collection there is an implement precisely like this, but mounted at the end with an extra blade of sheet iron, secured by sinew, and in the shape of a scraper, for which the instrument, thus mounted, was well adapted.

*Bone Moccasin Smoother*—Fig. 13, Pl. IV.—This elaborate and singular implement was found with one end inserted behind a rafter in one of the Mandan houses, and was evidently forgotten by the Arickarees when they abandoned the village. The same person, Mrs. Culbertson, found the article, and presented it to the writer, and pronounced it, at the same time, a moccasin smoother. It measures  $13\frac{1}{2}$  inches in length,  $1\frac{1}{4}$  inch in width across the handle, and  $3\frac{1}{2}$  inches across the branches. It is white on the upper side, brown on the under, and an eighth of an inch thick. The handle is ornamented with a representation of two skin tents, and one of the branches with the figure of an elk. The remaining ornaments are simply dots burnt into the bone. It will be observed that the projections on the branches are somewhat triangular, being narrowest at the points of intersection. These may have been designed to hold the moccasin at different distances from the handle, while stretched over it for the purpose of rubbing down the seam, and perhaps while in the act of stitching. A great amount of labor was evidently expended in constructing this implement, in doing which, some metallic instrument would seem to have been necessary.

*Buffalo-Horn Spoon*—Fig. 14, Pl. IV.—The soup ladle, made of wood, is one of the most common utensils of the American Indians. It is used for eating soup, succotash and hominy, and also for drinking. This horn spoon was designed for the same purposes, and is made of the exterior sheath of the horn of the buffalo. It is black in color,  $12\frac{1}{2}$  inches long,  $2\frac{3}{4}$  inches broad in its widest expanse, and  $1\frac{3}{4}$  inch in its greatest depth. In thickness it is one-eighth of an inch, and is translucent in places. It was probably softened in water, cut in its present form, and the handle bent slightly, and then allowed to harden in a fixed position. The tip of the horn, for an inch and a half in length, is in

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its natural state. It was certainly a convenient, as well as a useful utensil.

*Iron Tomahawk*—Fig. 15, Pl. V.—The early traders introduced an iron tomahawk of the kind represented in the figure, among a large number of our Indian nations. It is often found in Indian graves in New York and elsewhere, buried with other personal articles; but it was never very highly valued. This has the usual stamp of the manufacturer on both sides of the blade, which, in this case, although nearly rusted out, appears to be 8 R. Since it is a foreign article, it scarcely requires any notice.

#### WOODEN IMPLEMENTS OF THE ARICKAREES.

*Wooden Corn Mortar*—Fig. 16, Pl. V.—The Village Indians of New Mexico ground their corn with the metate or stone grinder, by rubbing the corn with it upon a flat or slightly concave stone adjusted at an inclination; but the Northern agricultural and Village Indians used a wooden mortar with wooden pounder to reduce their corn to meal. That of the Iroquois was large, two feet high, fifteen inches in diameter, and with a cavity which would hold nearly a peck of corn. It stood upon the ground, and the pounder was about four feet long. That of the Mandans and Arickarees was much smaller, sunk in the ground floor of the lodge, within two inches of the surface. Each of the houses at the Mandan village was provided with one, and sometimes with two and three of these mortars. The one about to be described, I removed from its position in the ground floor, and brought it away with me, with its pounder. It is a section of an ash tree, with the bark still upon it, 17 inches high, 9 inches in diameter at the top, and  $7\frac{1}{2}$  inches at the bottom. The cavity is like the interior of an urn, except that it terminates acutely. It is  $9\frac{1}{4}$  inches deep, 5 inches in its greatest diameter and  $3\frac{3}{4}$  inches at the neck or mouth, as shewn in the figure (Fig. 17, Pl. V). As it will hold less than two quarts of corn, about a pint probably was the amount pounded at a time. The pounder (Fig. 18, Pl. V) is a hickory stick,  $4\frac{1}{2}$  inches in diameter, and 3 feet 3 inches long. In the figure the ends should have been reversed. To form a handle, the stick is reduced to two inches in diameter, leaving the upper end, for six inches in length, its natural size, to add by its weight to the momentum of the blow. It weighs  $5\frac{1}{2}$  pounds. The small end, with which the corn is crushed, has a blunt edge. In the

earliest period, corn was probably pounded in stone mortars and with stone pestles. When the wooden mortar was introduced, is unknown; but it is probable that it came into use before the epoch of European discovery.

*Ladder*—Fig. 19, Pl. V.—The Indians knew the uses of the ladder, and some of them manufactured an excellent article before the discovery of America. When Coronado visited and subdued the seven so-called cities of Cibola, in New Mexico, in 1540–2, he found the people living in seven or eight large communal houses, each capable of accommodating a thousand or more persons. In the account of this expedition by Coronado, we have the first mention of the ladder used by the Northern Village Indians. Their houses were without entrances upon the ground floors; but they mounted to the first terrace by means of ladders, and so to each successive story above; “and the ladders which they have for their houses are all in a manner movable and portable, which are taken away and set down when they please, and they are made of two pieces of wood, with their steps as ours be.”\* The Arickarees, Mandans and Minnitasees use finely made ladders for the purpose of ascending their drying scaffolds before mentioned, and to the tops of their houses. There was one or more of these at every scaffold. They were made of two limbs growing nearly parallel, and severed below the junction, as shown in the figure, and set with the forked end upon the ground and the two ends against the scaffold. Depressions were sunk in the side rails to receive and partially hold the rounds, which were secured by rawhide strings. In this manner they produced a neat, strongly made and excellent ladder. They were usually from ten to twelve feet long.

*Willow Matting*—Fig. 20, Pl. V.—Screens, or matting, made of willow answered many useful purposes in the domestic economy of the Arickarees and Mandans. Willows grow abundantly in places on the Upper Missouri. From their pliable character and nearly uniform diameter they make excellent mats and screens. They are cut about six feet long, and, after being dried, are woven into mats by the simple process of passing two strings of raw hide or of filaments of bark, the one over and the other under each cane, both near the ends and at the centre, until a mat is produced from eight to twelve feet long, according to the use

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\* Coronado's Relation. Hakluyt's Coll. of Voyages, London Ed., 1812, v. 5, p. 498.

for which it is designed. The willows used are about half an inch in diameter. This matting is used to cover the rafters of a new lodge; after which they are spread over with grass, upon which is placed the covering of earth which forms the roof. They are also used, as well as skins, to form compartments for the several families which inhabit the same lodge, and for many other purposes. The introduction of the willow mat was a small invention; but yet it reveals a tendency to improvement as well as actual progress in the direction of increased comfort in domestic life.

*Caches for Corn.*—For storing corn, vegetables and dried meat, they excavated small cellars, sometimes by the side of the house, but quite frequently within it and near its walls. They are jug-shaped, the mouth being narrow and round, resembling in outline the cavity of the corn mortar (Fig. 16). They are usually from five to eight feet deep and from five to six feet wide in their greatest diameter. I measured one and found it six feet deep, and five feet wide at the bulge, with an opening at the surface two feet and three inches in diameter. It descended vertically about a foot, and then gradually widened out. As the soil was firm, it had not yielded or broken out in the least, and was perfectly fresh, dry and clean within. Whether the inner wall had been solidified by pounding the inner surface, I had no means of ascertaining. They are undoubtedly impervious to water, otherwise they would be useless, if not positively injurious.

*Pottery.*—In 1862 the Arickarees were still using pottery of their own manufacture. It was of a dark color, nearly black. While at the new Arickaree village, I saw them use earthen pots to draw water from the river. One of these, which would hold about six quarts, with a string adjusted around the neck, was let down into the Missouri, filled and then carried to the lodge. It was of the usual shape of earthen pots or water jars, slightly contracted at the neck and bordered with a rim, around which the string was secured.

*Mandan Village.*—This village was situated on the southwest side of the Missouri, upon a bluff forty or fifty feet high at a bend in the river, which here formed an obtuse angle, the river washing the base of the bluff. At the angle formed by the bend was the village plot, occupying a nearly circular area, and covering about five acres of land. A ground plan of the village is given in

**Figure 21 (Pl. VI).** Around the village, except on the line of the bluff, was a stockade, ten or twelve feet high, made of timbers inserted vertically in the ground ; but then in a dilapidated state. It is situated on the prairie, without a tree in sight for miles, except upon the bottom lands along the river between the bluffs. Grass grows luxuriantly upon the undulating surface, presenting a landscape of unusual beauty. Buffaloes were grazing at the time of our visit, within a mile of the village, a spectacle probably which had not been witnessed since the Mandans established themselves at this point : thus showing how quickly the wild animals return to their former haunts after man has departed.

The houses were circular in external form, the wall being about five feet high, and sloping upward from the ground with an inclined roof, both exterior wall and roof being plastered over with earth a foot and a half thick. In Figure 22, (Pl. VI.) a ground plan of the Mandan lodge is given. These houses are about forty feet in diameter, with the floor sunk a foot or more below the surface, six feet high on the inside on the line of the exterior wall, and from twelve to fifteen feet high at the centre. They are timber-framed, and superior in design and mechanism to any houses constructed by Indian nations north of New Mexico and Southern Utah. Twelve posts, six or eight inches in diameter, are set in the ground at equal distances in the circumference of a circle, and rising about six feet above the level of the floor. String pieces, resting on forks upon the top of each post, connect them with each other, thus forming a polygon at the base of the roof and also upon the ground floor. Against these, and opposite to each post, an equal number of braces are sunk in the ground about four feet distant, which, slanting upward, are adjusted by means of forks or depressions cut in the ends, so as to hold both the posts and the stringers firmly in their places. Slabs of wood or round timbers are then placed in the spaces between the braces, at the same inclination from the ground, and resting against the stringers, which when completed surrounded the lodge with a wooden wall. Four posts, each six or eight inches in diameter, are set at the four angles of a square in the centre, ten feet apart, and rising from twelve to fourteen feet above the floor. These are again connected by stringers resting in forks on their tops, upon which and the external walls the rafters rest. A cross section of the house is shown in Figure 23, (Pl. VI.) which exhibits the interior framework here described. Poles three or four inches in

diameter are placed as rafters from the external walls to the string pieces upon the central posts, and near enough together to give the requisite strength to support the earth-covering which formed the roof. These poles are first covered over with willow matting of the kind previously described, upon which prairie grass was spread, and over this a deep covering of earth. An opening was left in the centre about four feet in diameter, for the exit of the smoke, and for the admission of light. The interior is spacious and tolerably well lighted, although the opening in the roof was the only one through which light could penetrate. There is but one entrance, and that protected by an Eskimo doorway: that is, by a passage five feet wide, ten or twelve feet long and about six feet high, constructed with split timbers roofed with poles and covered on the top with earth. Buffalo robes suspended, both at the outer and inner entrances, supply the place of doors. Each house, when occupied, was comparted by screens of willow matting or unhaired skins suspended from the rafters, with spaces between for storage. These slightly constructed apartments extended back to the wall and opened toward the centre, thus defining an open central area which formed the gathering place of the inmates of the lodge. The fire pit was in the centre, about five feet in diameter and a foot deep, and encircled with flat stones set up edgewise. A hard smooth earthen floor completed the interior. Such a lodge would accommodate five or six families of related persons. In fact it was a communal house, in accordance with the usage and institutions of the American aborigines, and growing naturally out of their customs and mode of life. I counted forty-eight of these houses which would average forty feet in diameter, besides several rectangular houses constructed of hewn logs at a more recent day. The roofs of several of them had fallen in, leaving the outer walls still standing; but a number of them were perfect, just as the Arickarees left them several months before, with strings of corn still hanging upon poles and broken articles of various kinds scattered around. A front elevation of the Mandan house will be found in Figure 24, (Pl. VI).

Not the least interesting fact connected with these creditable Indian homes, was the quantity of material each lodge required in its construction and the amount of labor necessary for its transportation, long distances down the river, and to fashion it with the aid of fire and stone implements into a comfortable dwelling, such as has been described. Wood is scarce and of inferior



quality on the upper Missouri: and to cut it without metallic implements, and to transport it without animal power, which was their hard necessity, indicate a degree of persevering industry highly creditable to a people who are generally regarded as averse to labor. It is not unlikely that some of the stone hammers and mauls, herein figured and described, were worn off in the erection of these houses, and that these, with stone chisels, were the only implements used.

These houses were thickly studded together to economize the space within the stockade, so that in passing through the village, you walk along semi-circular foot paths which turn at a few paces both to the right and left. There is not only no street, but it is impossible to see in any direction except for short distances, and very difficult to find your way until the topography of the village is learned. The foot paths tread a labyrinth of circular houses, as will be made apparent by consulting the ground plan of the village (Figure 21). In the centre there was an open space several rods in diameter, where their dances, games and religious ceremonies were performed, and where the people gathered for general intercourse and for holding councils. The medicine stone, a boulder of granite, spotted over with vermilion, and the war-post, were still in their places in this area within a circular picket enclosure. Upon the housetops, which furnished attractive resorts for lounging in the sunshine, were skulls of the buffalo, sometimes three or four, placed there from religious motives of some kind, but appearing to the stranger as very proper trophies of the chase.

In the open spaces between the houses were their drying scaffolds, about one to each house. They were about twenty feet long, twelve feet wide, and seven feet high to the flooring, and made of posts set upright with cross pieces resting in forks (Fig. 25, Pl. VI). Other poles were then placed longitudinally, upon which was a flooring of willow mats. At the four corners and midway at the centre, extra posts were set, and rising to the height of fifteen feet, were connected with three cross pieces at the top placed transversely and resting in forks, which completed the frame work. These wooden scaffolds, mounted with ladders of the kind described, were used for drying their skins and also their corn, meat and vegetables.

Situated thus picturesquely on a bluff at an angle of the river, with houses of such peculiar model, and with such an array of

scaffolds rising up among them, the village was strikingly conspicuous for some distance, both above and below on the river, and presented a remarkable appearance.

Afterwards, at the Minnitasee and Mandan village, higher up the river, and at the new Arickaree village, I had an opportunity to see houses precisely similar in actual occupation. The Mandans, immediately before their calamitous visitation by the pestilence, numbered two thousand, and the Arickarees, at the time of their removal, nine hundred.

*War Post.*—In the centre of the village, as elsewhere stated, were the medicine stone and the war post, both inherited probably from the Mandans, as we found a similiar stone and post at the Minnitasee and Mandan village, in a similar area in the centre, and in a picket enclosure. The war post was a red cedar tree about seven feet long and three and a half inches in diameter. The rough bark had been removed and the top ornamented with strips of red flannel. It was set about two feet in the ground. I raised it and brought it away with me, as a memorial of the Mandans. It has been the silent witness of many barbarous rites of cord-swinging and dragging buffalo skulls: in the first case the devotee suspending himself with cords passed through the skin on the shoulder blades, and in the other, dragging one, and sometimes, two buffalo skulls attached in the same manner. If it could speak, it might unfold many singular ceremonies illustrative of the religious fervor and dark superstitions of this remarkable people.

*Grave Mounds.*—The Arickarees buried their dead in the ground, and in a sitting posture, judging from the form and size of the mounds. Just back of the village upon the open prairie, was a long row of these mounds quite near together. There were several hundred of them forming a segment of a great circle apparently a mile in length. They were about three feet high, seven feet long and five feet wide at the level of the ground. Other mounds were grouped together. The most conspicuous mound was that of an Arickaree chief killed by the Sioux a few years before. It was somewhat larger than the others, with a smaller mound, probably that of a relative intersecting it. Around the two, the sod had been removed for the space of five feet, thus forming an area fifteen or more feet in diameter, with a floor of bare earth, the mounds being in the centre. On the top of the mound over the chief's grave, were two bull buffalo skulls, side and

side, their horns wound with strips of red flannel and the forehead of one spotted with vermilion. The outer border of the cleared area was decorated with seventeen buffalo skulls, occupying about two-thirds of the circuit, and enclosing the grave of the chief. With what religious motive these skulls were used in their burial customs was not ascertained. The Mandans buried their dead upon scaffolds, which was a common method among a large number of our Indian nations. None of these scaffolds remained at the old village in 1862. There was one scaffold standing, and this upheld the body of a Sioux, who had probably become domesticated among the Arickarees, and dying there, had been buried according to the customs of his nation. The Minnitasee and Mandan village, sixty-five miles above, is situated upon a bluff at a bend in the river in a situation precisely similar to that of the old Mandan village, but upon the north-east side of the Missouri. It contains about the same number of houses, of the same design, and is surrounded, except on the bluff, with a wall of wooden pickets set close together vertically in the ground, and rising to a height of ten or twelve feet, with two or three gateways or openings. Back of the village, about half a mile in the prairie, was the field of scaffolds. They were thickly studded together, about two hundred in number, and some of them containing more bodies than one. Four posts or poles are set in the ground, about eight feet high, with stringers and cross pieces resting in forks, upon which a flooring of smaller poles is placed, all of which are secured with raw hide strings. This is covered with a buffalo robe. The body dressed and painted, and wrapped in blankets, red or blue, is then placed upon the scaffold and lashed to it with strips of raw hide. One partially uncovered, showed the head resting on a pillow, the arms crossed on the breast, and a pipe of catlinite with a long wooden stem, laid by his right side, resting on the shoulder. At the foot of the body was a detached bundle, probably containing clothing and food, lashed to the scaffold. Many nations who scaffold the remains of the dead, use this method as a temporary burial, gathering the bones at a later period and depositing them in a separate lodge near their dwellings. Burying the dead in the ground, out of sight, they regard as an evidence of want of affection for deceased relatives.

*Winter Village.*—Some miles above the old Mandan village, and upon the opposite side of the river, was another village of the

Arickarees, constructed for winter use. It contained thirty or forty houses of the same model and size, but not so well built. They wintered at this village to be nearer game and fuel. Their horses were stabled within the house of their owners for safety as well as comfort, man and beast being warmed by the same fire and covered by the same roof. All the people did not remove—only those in the best condition to follow the hunt. They returned in the spring in time for the planting season. This village was unoccupied at the time of our visit.

We remained at the old Mandan village but one night and a part of two days, and left it intending to stop again on our return down the river; but in this expectation we were disappointed. With another day at this village, the number and variety of implements and utensils might have been largely increased.

Respectfully submitted,

LEWIS H. MORGAN.

ROCHESTER, *January*, 1868.

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## ON THE MINERALOGY OF THE LAURENTIAN LIMESTONES OF NORTH AMERICA.

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### INTRODUCTION.

In a general report of the Geological Survey published in 1863, under the title of the *Geology of Canada*, the ancient gneissic system of the Laurentides of Canada and the Adirondacks of New York, is described under the name of the Laurentian system. Farther researches have shown that under this title were included two distinct and unconformable groups of rocks, which have since been distinguished as the Lower Laurentian and the Upper Laurentian, or Labrador series. The first and most ancient of these, to which it will be well for the future to restrict the name of Laurentian, corresponds to the primitive gneiss of Scandinavia and of the west of Scotland. This opinion was put forward by the author in 1855, and has since been confirmed by Sir R. I. Murchison, for Scotland. More recently, Messrs Gumbel and Hochstetter, after a lengthened study of the older gneiss of Bavaria and Bohemia, have declared it to be identical with the Laurentian of North America, a conclusion sustained by the discovery by Gumbel of the fossil remains of the rhizopod *Eozoon Canadense*, in the limestone of the Bavarian gneiss.

The lower or true Laurentian consists in great part of orthoclase gneiss, sometimes granitoid, with quartzites, occasionally becoming conglomerates; hornblendic and micaceous schists, pyroxenites, serpentines and limestones, sometimes magnesian. These limestones, generally very crystalline, are seen on the Ottawa, in

the counties of Argenteuil and Grenville, to form three distinct formations, having each a thickness of from 1,000 to 1,500 feet, separated, underlaid and overlaid by still greater masses of gneiss and quartzite. The measured thickness of this series on the Ottawa is more than 20,000 feet, which is probably far from representing its total volume, while in Bohemia it is supposed to equal not less than 90,000 feet. In the county of Hastings, in the province of Ontario, not less than 21,000 feet of strata, consisting of crystalline schists, limestones and diorites, are found resting conformably upon Laurentian gneiss.\* It appears certain, however, that this series, which differs both in the succession and the lithological character of its strata from the sections in the Ottawa valley, belongs to the Lower Laurentian, of which it would appear to constitute a member higher in the system than any observed in New York or in the province of Quebec, so that the whole known thickness of the Lower Laurentian in Canada would surpass 40,000 feet. The *Eozoon Canadense* is met with in several localities, both in the lower and higher members of the Lower Laurentian.

The Labrador (or Upper Laurentian) occurs in detached areas, resting unconformably upon the true Laurentian system. Some of these areas are many miles in breadth, and they occur at intervals in Canada from the shores of Lake Huron to the coast of Labrador. The Labrador series contains strata of orthoclase gneiss, quartzites, and crystalline limestones; but its predominant element is an anortholite—a rock composed essentially of a feldspar of the anorthic or triclinic system, generally with a small admixture of pyroxene or hypersthene. This anortholite is sometimes gneissoid, and even fine-grained; but is more often granitoid, and occasionally presents large cleavable masses of opalescent feldspar, generally labradorite or andesine. The thickness of this Labrador series cannot be less than 10,000 feet, and is perhaps much more. The true Laurentian offers nothing similar to these anortholites, which seem to be identical, both lithologically and geognostically, with the norites of Norway. They are the hypersthénites of the Hebrides, described by McCulloch, and subsequently recognized by Emmons under the name of hypersthene rock in the Adirondacks, of which, according to him, they form some of the highest summits.

To these two great series of ancient rocks must be added a third—the Huronian, which attains on Lake Huron a thickness of

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\* See postscript on page 98.

not less than 18,000 feet, where it lies between the Laurentian and Silurian systems, conformable with neither. It is believed to be newer than the Labrador series, though the two have never yet been seen in contact. The recent observations of Prof. Hall, have shown that the Huronian system is found interposed between the Silurian and the Laurentian to the west of the Mississippi, while it appears to have been very recently identified both in Newfoundland and in New Brunswick. Of these three great series, Sir William Logan remarks that their united thickness "may possibly far surpass that of all the succeeding rocks from the base of the Potsdam series to the present time. We are thus carried back to a period so far remote, that the appearance of the so-called primordial fauna may by some be considered a comparatively modern event. We find, however, that even during the Laurentian period, the same chemical and mechanical processes which have ever since been at work disintegrating and reconstructing the earth's crust, were in operation, as now. In the conglomerates of the Huronian series, there are enclosed boulders derived from the Laurentian, that seem to show that the parent rock was altered to its present crystalline condition before the deposit of the newer formation, while interstratified with the Laurentian limestones, there are beds of conglomerate, the pebbles of which are themselves rolled fragments of a still older laminated sand-rock; and the formation of these beds leads us still further into the past." (*Quar. Jour. Geol. Soc.*, February, 1865.)

The area occupied by the Laurentian rocks in Canada, is about 200,000 square miles, of which about 1,500 square miles have been accurately studied and mapped in the valley of the Ottawa, in the province of Quebec, and a still smaller area in the county of Hastings, Ontario. The Laurentian area of the Adirondacks, in northern New York, comprises about 10,000 square miles, but has never yet been stratigraphically studied, although much attention has been paid to the mineralogy of the limestones of the series, which present many characters both of scientific and of economic interest. The following pages are extracted from the Report of the Geological Survey of Canada for 1863-66 (pages 182-223), published at Ottawa, and here reprinted with some few additions, which are distinguished by being enclosed in brackets :

The evidence afforded by the careful stratigraphical study of these Laurentian limestones, and their associated rocks in the val-

ley of the Ottawa, left, as we have seen, no doubt of their sedimentary nature and origin. Similar limestones in the Highlands of New York and New Jersey were long since recognized by Rogers, by Mather, and by other American geologists, as in like manner altered stratified rocks, which were by some regarded as of Silurian age, and by others of greater antiquity. The observations made by Sir William Logan and Prof. James Hall, in 1864 (*Amer. Jour. Science* [2], xxxix, 97), in the Highlands of the Hudson, however, leave no doubt that these limestones, and their accompanying gneissoid strata, belong to the Laurentian system.

The study by the late Dr. Emmons of the similar series of rocks, constituting the mountain region of the Adirondacks in northern New York, and continuous with the great Laurentian area of Canada, led him, however, to regard the limestones of the series as of igneous origin, and in fact as intrusive rocks. (See his Report on the Geology of the First District of New York, published in 1842, pages 37-59.) This view, although in contradiction with the conclusions of other geologists who have examined these Laurentian limestones in Canada and the United States, was not so singular as might at first sight appear. Mather, in his Report on Second District of New York (page 485), while maintaining the sedimentary and metamorphic nature of the crystalline limestones of the Highlands, asserted that there were examples in Washington county fully sustaining Emmons' view that such limestones sometimes occur as eruptive rocks.

Many of the first geologists of other countries have also maintained the igneous origin of certain crystalline limestones. Thus, in 1863, we find Von Leonhard asserting that limestones have sometimes come from the interior of the earth in a liquid state, like other igneous rocks. A similar view was at that time maintained by Guidini with regard to the dolomites of Spezzia in northern Italy, and by Rozet for similar rocks at Oran in Algeria, and for the crystalline limestones of the Vosges, which, like those of the Laurentian series, occur in gneiss, and are often mingled with serpentine. (*Bull. Soc. Geol. de France*, iii, pages 215 and 235.) These observers, like Dr. Emmons, urged in support of their view, among other reasons more or less fallacious, the undoubted fact that such limestones, in some cases, apparently form dykes or veins, which, like those of granite and greenstone, traverse gneissic or quartzose strata.



It has been pointed out in the *Geology of Canada* (pages 28 and 643), that, in the case of the Laurentian limestones, there is abundant evidence that they were at one time in such a plastic condition that external forces were able, not only to contort great masses of limestone, and to break and fold in a remarkable manner certain interstratified quartzose layers, but to force the softened limestone into fissures in the adjacent silicious strata. Examples of the latter phenomenon are, however, comparatively rare, and the limestone veins upon which Mr. Emmons, and probably other observers, have founded their view of the igneous origin of crystalline limestone, remain to be described, after a brief account of the limestones and their immediately associated strata. It should here be mentioned that Bischof considers the great dykes of granular limestone, which, near Auerbach in the Bergstrasse, are met with traversing gneiss, to be deposits from water, filling up fissures; in fact, veritable veinstones. (*Chem. Geol., English Ed.*, iii, pp. 148-150.) See also the note on page 47 for a description of a similar calcareous vein.

The Laurentian limestones of North America, and other crystalline limestones in different regions, some of which belong to other geological periods, often abound, as is well known, in foreign minerals. These occur disseminated through the mass of the rock, of which they serve, in many cases, to mark the lines of stratification. While some beds consist of nearly pure carbonate of lime, others will be found to be characterized by an admixture of grains or crystals of chondrodite, pyroxene, serpentine, mica, feldspar, quartz, graphite, or other minerals, either alone or variously associated, and sometimes in such quantities as to make up a large proportion of the rock.

Recent investigations have shown that in some cases the dissemination of certain of these minerals through the crystalline limestones is connected with organic forms. The observations of Dr. Dawson and myself on the *Eozoon Canadense* showed that certain silicates, namely, serpentine, pyroxene and loganite, had been deposited in the cells and chambers left vacant by the disappearance of the animal matter from the calcareous skeleton of that foraminiferous organism, so that when this calcareous portion is removed by an acid there remains a coherent mass, which is a cast of the soft parts of the animal, in which not only the chambers and connecting canals, but the minute tubuli and pores are represented by solid mineral silicates. It was shown that this

process must have taken place during the life of the animal or immediately after its death, and must have depended upon the deposition of these silicates from the waters of the ocean.

The train of investigation thus opened up has been pursued by Dr. Gümbel, Director of the Geological Survey of Bavaria, who, in a recent remarkable memoir presented to the Royal Society of that country, has detailed his results.

Having first detected a fossil identical with the Canadian Eozoon (together with several other curious microscopic organic forms not yet observed in Canada), replaced by serpentine in a crystalline limestone from the primitive gneiss of Bavaria, which he identifies with the Laurentian system of this country, he next discovered a related organism, to which he has given the name of *Eozoon Bavaricum*. This occurs in a crystalline limestone belonging to a series of rocks more recent than the Laurentian, but older than the primordial zone of the Lower Silurian, and designated by him the Hercynian clay-slate series, which he conceives may represent the Cambrian system of Great Britain, and perhaps correspond to the Huronian series of Canada and the United States. The cast of the soft parts of this new fossil is, according to Gümbel, in part of serpentine and in part of hornblende.

His attention was next directed to the green hornblende (pargasite), which occurs in the crystalline limestone of Pargas, in Finland, and remains, when the carbonate of lime is dissolved, as a coherent mass, closely resembling that left by the irregular or acervuline varieties of Eozoon. These grains are described as somewhat cylindrical in form, with rounded and pitted surfaces, presenting re-entering angles, and resembling, on a small scale, the tubers of some plants. Though thus destitute of external crystalline form, they have a perfect cleavage, and are entirely crystalline within. These small tuberculated grains are joined together by short cylinders, and are occasionally traversed by cylindrical openings; besides which, there are implanted upon them small cylinders, often branched, and resembling exactly in size and arrangement the casts of the tubuli of Eozoon, in which, or in some related organic structure, he conceives the pargasite to have been moulded. A white mineral, probably scapolite, was found to constitute some tubercles associated with the pargasite, and the two mineral species were in some cases united in the same rounded grain.

Similar observations were made by him upon specimens of coc-

colite, or green pyroxene, occurring in rounded and wrinkled grains in a Laurentian limestone from New York. These, according to Gmbel, present the same connecting cylinders and branching stems as the pargasite, and are by him supposed to have been moulded in the same manner. The continuity of the casts of the tubuli appears to have been, for the most part, destroyed by the subsequent crystallization of the carbonate of lime, in more compact portions of which they are, however, occasionally preserved. The fine residue from the solution of the lime in acids gave other minute organic forms, similar to those noticed by him in the Eozoon limestone of Bavaria. Very beautiful evidences of the same organic structure, consisting of the casts of tubuli and their ramifications, were also observed by Gmbel in a finely crystalline limestone, enclosing granules of chondrodite, hornblende, and garnet, from Boden, in Saxony. Other specimens of limestone, both with and without serpentine and chondrodite, were examined without exhibiting any traces of these peculiar forms, and these negative results are justly deemed by Gmbel as going to prove that their structure is really, like that of Eozoon, the result of the intervention of organic forms. In this connection, an observation made by Sir William Logan with regard to the Eozoon rock of Canada is very important, namely: that the granular mixture of carbonate of lime and serpentine which accompanies the perfect forms of Eozoon, consists of broken and comminuted portions of the fossil, still exhibiting minute structure, and having a stratified arrangement. Besides the minerals mentioned above as having been observed as the replacing substance of the Eozoon in Canada, namely, serpentine, pyroxene, and loganite, Gmbel adds chondrodite, hornblende, scapolite (?), and probably, also pyralloolite, quartz, and iolite or dichroite.

Accompanying the crystalline limestones of the Laurentian system in Canada, are often found strata made up of foreign minerals to the entire exclusion of carbonate of lime, by an admixture of which, however, they gradually pass into the adjacent limestones. These strata generally consist of pyroxene, sometimes nearly pure, and at other times mingled with mica, or with quartz and orthoclase, often associated with hornblende, epidote, magnetite, sphene and graphite. These beds, which may for the most part be described as pyroxenites, from the prevailing mineral, and which have been briefly noticed in the *Geology of Canada*, page

475, are generally granitoid or gneissoid in structure. They are sometimes fine grained, and at other times made up of crystalline elements from two-tenths to five-tenths of an inch in diameter. They occasionally assume a great thickness, and are then often interstratified with beds of granitoid orthoclase gneiss, into which the quartzo-felspathic pyroxenites pass by a gradual disappearance of the pyroxene. These peculiar strata, which contain at the same time the minerals of the associated gneiss and of the limestones, may thus be looked upon as beds of passage between the two rocks. Their mineral species and varieties, so far as my observations go, are, identical with those of the limestones themselves. It should be remembered that, besides the minerals already mentioned as predominating in these strata, other species characteristic of the limestones, such as serpentine and magnetite, sometimes make up by themselves great beds in these intermediate or transition strata, which, from their mineralogical relations, may all be looked upon as related to the accompanying limestones. In some districts, however, hornblende predominates over the pyroxene, and gives rise to beds of pure hornblende rock, or amphibolite, sometimes schistose, and to compound rocks, such as diorite and hornblendic gneiss, so that each group of limestones, with its attendant pyroxenites, amphibolites, serpentines, magnetites, etc., may be considered as characterizing an epoch in the geological period to which it belongs.

Each one of the three great limestone formations which have been recognized in the Laurentian system on the Ottawa, appears to be associated with these related rocks, which are, however, in some parts, developed to a great extent, and in others are comparatively unimportant in volume. These limestone groups, as we may hereafter designate the limestones with their attendant rocks, appear to be the parts of the system to which the principal economic minerals belong. The ores of iron, copper, nickel and cobalt, the apatite, mica and plumbago, as well as the serpentines and the marbles of the great Lower Laurentian series, belong, so far as yet known, to the limestone groups.

The Labrador or Upper Laurentian series includes one, and perhaps more limestone bands, which, so far as ascertained, present the same mineralogical accompaniments as the limestone formations of the Lower Laurentian.

#### MINERAL VEINS.

We may now consider the mineral veins which traverse the

Laurentian rocks, and have chiefly been studied in connection with these limestone groups, where they present the most varied and important mineralogical characters. These veins have been briefly described in the *Geology of Canada*, pages 35-37, where three classes of them are distinguished as follows :

1. Veins filled chiefly with calcareous spar, sometimes with sulphate of barytes or fluor-spar, and carrying sulphuret of lead, and more rarely, sulphurets of zinc, iron and copper. Numbers of these metalliferous veins have been described in speaking of the various metals in chapter xxi of the *Geology*, and others are noticed by Mr. Macfarlane in his report on the county of Hastings (*Geol. Survey of Canada*, 1866). These veins are much newer than the Laurentian rocks, since they traverse in Ramsay, Ontario, the strata of the Calciferous formation (*Geol. Can.*, page 636). Similar veins are also met with in Lewis county, New York, intersecting the limestones of the Trenton group, and sometimes containing fluor-spar. The vein in the Laurentian limestone on Muscalunge lake, St. Lawrence county, New York, which contains besides calcite, the huge crystals of fluor-spar so well known to mineralogists, may probably belong to the same class as the lead-bearing veins just mentioned.\*

2. The veins of the second class are filled with quartz and orthoclase feldspar, which is sometimes replaced by, or associated with albite. These veins occasionally include crystals of black or white mica (muscovite), large crystals of black hornblende, and not unfrequently black tourmaline, red garnet and zircon. One of this class, cutting the Laurentian gneiss in Greenfield, near Saratoga, New York, contains, in addition to garnet and tourmaline, the rare species chrysoberyl; and the granitic vein holding crystals of beryl, observed by Dr. Bigsby in the gneiss of Rainy

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\* In this connection may be mentioned a vein of this class, remarkable for its size, which occurs at Spencerville, near Prescott, Ontario, and has attracted some attention in the neighborhood. It is on the east half of lot twenty-eight, in the sixth range of Edwarsburg, and cuts the horizontal strata of the Calciferous formation, which is here bare of soil, and holds nodules of chert. The vein, which runs E. N. E., has been traced on the surface for a distance of about one hundred rods, and at the place where it has been opened is not less than eighteen feet wide, and vertical in its attitude. A pit had been sunk on the vein at the time of my visit, in August, 1864, to depth of twenty feet. The veinstone was pure white crystalline carbonate of lime, without any traces of banded structure; and in detached blocks the greater part of it could not be distinguished from many saccharoidal limestones. Occasionally, however, masses of a coarsely cleavable and lilac-colored calcite were met with. The only foreign minerals in this vein were small and rare grains of copper pyrites, and more frequently, iron pyrites in thin testaceous crusts, also very sparsely distributed. Another, and a smaller vein, was observed nearly parallel to this, filled with a similar carbonate of lime, but without any visible metallic impregnation.

Lake, possibly belongs to Laurentian rocks (*Geol. Can.*, page 492). These veins, from their constituent minerals, are generally described as granitic, but are not to be confounded with injected granite dykes, since they are doubtless true veins, like those of the first class, filled by the gradual deposition of matters from aqueous solutions. These granitic veins, unlike those of the preceding class, have not been observed to intersect the Silurian rocks, and are probably of greater antiquity than they. As will hereafter be shown, they cannot be distinguished from the veins of the third class, into which they pass by insensible degrees.

3. In the third class were included, in the *Geology of Canada*, those veins which appear to be more nearly related to the limestone groups, with which they are generally associated, and with the characteristic minerals of which they are filled. These veins are extremely numerous, and exhibit, within certain limits, remarkable variations in mineralogical characters. The most important elements of these veins are calcite, quartz, orthoclase, phlogopite, pyroxene, apatite and graphite, of which some one or more will be found to prevail; but they may contain, besides, numerous other species, including nearly every one to be met with in the limestones, and in their accompanying pyroxenic and gneissic rocks. Veins of the present class are found traversing all these strata; they are most frequently vertical in attitude, and generally cut the beds at right angles, though to this many exceptions may be cited. They exhibit, within certain limits, great variations in their mineralogical characters, not only in different veins, but in different parts of the same vein. Thus, in some cases, pyroxene is the predominant mineral, and other species are present only in small quantities. At other times, orthoclase, apatite, or magnesian mica makes up the great mass of the vein, and in other cases, calcareous spar. It is the veins of this latter mineral which have doubtless been, by Emmons and other observers, described as intrusive veins of crystalline limestone. Having generally a solidly crystalline lamellar structure, very unlike the more or less cavernous calcareous veinstones of the first class, and sometimes holding only sparsely disseminated crystals of one or more of the minerals which are common to the stratified limestones, such as pyroxene, mica, or apatite, the observer will often find it difficult to determine whether a detached mass, or an imperfectly displayed out-crop of crystalline limestone, belongs to a bed or a vein. When, however, it is possible to make a thorough exami-

nation of the locality, it will be found in the latter case that the deposit occurs in a fissure cutting the stratification, and as well-defined walls.

A banded arrangement of the mineral contents is often very well marked. Thus, while the walls may be coated with crystalline hornblende, or with phlogopite, the body of the vein will be filled with apatite, in the midst of which may be found a mass of crystalline orthoclase, or of loganite, occupying the centre of the vein. In other instances, portions of the vein will be occupied by crystals of apatite, pyroxene, or phlogopite, imbedded in calcareous spar, which, in some other part of the breadth of the vein, or in its prolongation, will so far predominate as to give to the mass the aspect of a coarsely crystalline lamellar limestone. Most of the well crystallized minerals described by observers, both on this continent and in Europe, as occurring in crystalline limestones, appear to be derived from calcareous veins like those just described.

In like manner I have described localities of crystallized apatite as occurring in beds of limestones in Burgess, Ontario, where a subsequent examination (while confirming the existence of this mineral in the limestone beds of that region) has shown, nevertheless, that the workable deposits are with few, if any, exceptions confined to the veinstones.

From a lithological point of view, there cannot be any objection to extending the name of limestone to these calcareous veinstones; but geologically, it becomes important to discriminate between them and those great masses of limestone which are sedimentary deposits.

That these deposits of mineral matter, occupying fissures in the stratified rocks, are not intrusive veins or dykes, but have been formed by gradual deposition or accretion, is shown by the banded arrangement parallel to the walls, just noticed. Further evidence of this origin is seen in the manner in which the various minerals surround or incrust each other. Thus, small prisms of apatite are enclosed in large crystals of phlogopite, in spinel, and even in massive apatite; crystals or crystalline masses of calcite are imbedded in apatite and in quartz, and well-defined crystals of hornblende (pargasite) occur imbedded in others of pyroxene. In another example, small crystals of hornblende are implanted on a large crystal of pyroxene, and both of these are, in their turn, incrustated by small prisms of epidote. This latter crystal was

evidently from a drusy cavity, such as those often met with, representing unfilled spaces in the midst of the veins, and lined with large and well-defined prisms of apatite or of pyroxene.

While these associations evidently show a successive deposition of the various mineral species, another phenomenon, sometimes observed in vein-crystals, is presented by a prism of yellow idocrase from a vein-stone of orthoclase and pyroxene in Grenville, Quebec. One extremity of the prism, which is about half an inch in diameter, is imbedded in the matrix of the two minerals just named, while the other, being broken across, shows that the idocrase forms but a thin incrusting shell, and is filled with a confused crystalline aggregate of orthoclase, holding a small prism of zircon. This would show that a skeleton-crystal, such as is sometimes seen in crystallizing solutions, had at first formed, and was subsequently filled up with the other minerals. Similar cases are well known to mineralogists; thus the crystals of zircon from Laurentian veins in St. Lawrence county, New York, are sometimes filled with calcareous spar; and a granitic vein at Haddam, Connecticut, has afforded prisms of beryl filled with a mixture of orthoclase and quartz holding minute crystals of garnet and of tourmaline. A strong confirmation of the view that these minerals have been deposited in their veins from solution, is afforded by certain phenomena not hitherto explained, which were, I believe, first noticed by the late Dr. Emmons. He observed that crystals of quartz imbedded in crystalline limestone, in Rossie, New York, have their angles so much rounded that the prismatic form is almost or entirely effaced, the surfaces being smooth and shining. This appearance, although not constant, is observed in many localities, and is not confined to quartz alone—crystals of apatite and of carbonate of lime sometimes exhibiting the same peculiarity. At the same time as remarked by Dr. Emmons, the feldspar, scapolite, pyroxene, zircon and sphene of these limestones present perfect forms, the crystals of orthoclase, even in contact with the rounded crystals of quartz, retaining their sharpness of outline. Dr. Emmons considered the rounded angles of these crystals to be due to a partial fusion, though at the same time he did not overlook the fact that the quartz, apatite and calcite were less fusible than those species which, under similar circumstances, retained their crystalline forms intact (*Geology of the First District of New York*, pages 57, 58).

These observations have since been abundantly confirmed in



Canada. The crystals of apatite in Elmsley and Burgess, Ontario, rarely present sharp or well-defined forms; but whether lining drusy cavities, or imbedded in the calcareous veinstone, present rounded or sub-cylindrical crystalline masses, while the pyroxene and sphene, which often accompany them, preserve the sharpness of their angles. The hypothesis which would explain by igneous fusion this rounding of the angles, is evidently untenable, first, because the more fusible species show no signs of such action, and, second, because the carbonate of lime, which encloses and even penetrates the rounded quartz crystals, is not in any way affected at the surfaces of contact as it would have been by fused or half-fused quartz. This rounding of the angles of certain crystals appears to me to be nothing more than a result of the solvent action of the heated watery solutions, from which the minerals of these veins have been successively deposited, the crystals previously formed being partially redissolved as a result of some change in the temperature, or in the chemical constitution of the solution. Heated solutions of alkaline silicates, as shown by Daubrèe, are without action on feldspars, as might be expected from the fact, observed by him, of the production of crystals of feldspar and of pyroxene in the midst of such solutions. These liquids would, however doubtless attack and dissolve phosphate of lime, which is, in like manner, decomposed by solutions of alkaline carbonates, and these latter at elevated temperatures attack and dissolve crystallized quartz.

The regularity, and the frequently large dimensions of the crystals, not less than their modes of association, and the other phenomena just mentioned, serve to distinguish the minerals of these veinstones from the same species which are found disseminated in the limestone beds. In the latter case they sometimes occur in small distinct crystals, but more generally in rounded irregular grains, which present a marked contrast to the same minerals occurring in the veins. This rounded form of the minerals in the beds of limestone, is to be carefully distinguished from the rounding of the crystals in the veins just described, although the two phenomena have hitherto been confounded by those who have written upon the subject. In the latter case the rounding is by no means constant, and is confined to a few species, while in the limestone beds it will be found that a rounded form characterizes alike apatite and quartz, and such silicates as pyroxene, hornblende, serpentine and chondrodite. The rounded

shapes assumed by these minerals in limestone, and especially by the silicates just mentioned, have been noticed by Naumann and Delesse, among others; and the latter observer supposed that this condition might be due to a repulsive action between the particles of the silicates and the surrounding calcareous matter when both were in a plastic state under the influence of water and heat. The observations of Dawson and myself, and the latter ones of Gumbel, however, as detailed on pages 43 and 44, demonstrate that this rounded form, in many cases, at least, is due to no such subsequent action, but has been given by the calcareous organic structure, in whose chambers these silicates were originally deposited. It would, however, be premature to say that this explanation is of universal application, but it may be affirmed in general terms, that certain external forces have, in the limestone beds, prevented the free development which these mineral species naturally assume while in the veinstones. On the contrary, the rounding of the angles of certain crystals, to the exclusion of others, is due to a partial dissolution of the previously formed crystals.

As already remarked, it is impossible to draw any definite line between the veins just described and those already mentioned as placed in the preceding class, and generally designated as granitic veins. Most of their characteristic minerals are common to the two classes, and it is easy to trace a gradual change from the typical granitic veins, to those in which carbonate of lime is the predominant mineral, and which are to the crystalline limestones what the former are to gneiss and mica-schist. In both cases I conceive that they derive their mineral contents from the adjacent strata, whose fissures they fill, and are entitled to the name of segregated veins. In both cases, also, it must be borne in mind that other vacant spaces in the strata, whether resulting from contraction, solution, or other causes, may present conditions for deposition similar to those of fissures, and may thus give rise to drusy cavities, or to detached masses of crystalline minerals identical to those of the veinstones. This view of the origin of granitic veins from solution, and their distinction from intrusive granites, has been insisted upon by me in the *Geology of Canada*, pages 477, 644, and since, with more details, in my *Contributions to Lithology in the American Journal of Science* [2], xxxvii, 252.

To resume, then, it may be said that besides the fissures filled with igneous injected granite, forming what may be distinguished

as *granitic dykes*, there are other fissures which have, by a slow deposition from solutions, been filled with the constituent minerals of granite, constituting true *granitic veinstones*, which, unlike the granitic dykes, are often rich in foreign minerals. These aggregates pass by gradations into the pyroxenic and calcareous veinstones already noticed. It is from not knowing this distinction that Durocher, Fournet and others have perplexed themselves with strange hypotheses in attempting to explain the phenomena presented by the associations and juxtapositions of mineral species in granitic veinstones, which they imagined to have been formed, like granitic dykes, by the consolidation of a fused or pasty mass, instead of being the result of a slow deposition from solution. For convenience of definition, I have elsewhere distinguished these veinstones by the title of *endogenous* rocks, as describing the conditions of their formation. The intrusive dykes, on the other hand, I have called *exotic*, and the sedimentary strata, *indigenous* rocks.

. As to the conditions under which these various minerals have been crystallized, the beautiful researches of Sorby furnish us considerable light. The limestones, from Somma, near Naples, afford, in a finely crystallized state, the greater number of the mineral species met with in the Laurentian limestones of North America, and the crystals of hornblende, idocrase and orthoclase from that locality contain small cavities, often of microscopic dimensions, partially filled with water, holding in solution alkaline chlorides, sulphates and carbonates. As these cavities were filled with liquid during the formation of the crystal, the subsequent cooling has produced a partial vacuum ; this is again filled on heating the crystal to the temperature at which it was formed, which in this way may be approximately determined. Mr. Sorby found, by this method, that the hornblende, idocrase and feldspar from the limestones of Somma must have been crystallized at from 360° to 380° Centigrade, a temperature equal to that of low redness. The crystals from the granitic veins of Cornwall, including quartz, mica, orthoclase and oxyd of tin, all of which contain cavities holding watery solutions, have shown, in like manner, to Mr. Sorby, that these minerals must have been deposited at temperatures approaching those deduced for the minerals from the crystalline limestones of Somma, or from 200° to 340° Centigrade (from 392° to 644° Fahrenheit) (*Quar. Jour. Geol. Soc.*, London, xiv, 453). He thence concludes that these minerals have crystallized

at temperatures in some cases equal to that of low redness, under a pressure equal to that of several thousand feet of rock, and in the presence of water holding in solution a large amount of alkaline salts, which can in some instances be detected in the liquid from these cavities.

These conclusions are supported by the experiments of Daubrée, who succeeded in forming crystallized pyroxene, feldspar and quartz, in the presence of alkaline solutions at a low red heat. De Senarmont also obtained crystallized fluor-spar, sulphate of barytes and quartz, in the presence of water, at temperatures between 200° and 300° Centigrade. The deposits from the thermal waters of Plombières, however, show that some hydrous silicates, like apophyllite, harmotome and chabazite, may be crystallized at temperatures below that of boiling water, and there are reasons for believing that quartz may also be crystallized at low temperatures. Thus, while the observations of Sorby show the temperatures at which certain minerals have been crystallized, it does not necessarily follow that some of these crystals may not be generated at lower degrees of heat, which, for the minerals found in nature, must, in each case, be determined by experiments like those of Mr. Sorby.

It will be readily understood that the conclusions as to the conditions of temperature under which certain minerals have been crystallized, apply with equal force to those freely deposited in fissures or cavities of the sedimentary rocks, and those which may have crystallized in the midst of the deeply buried sediments themselves; since these must have been permeated with the same solutions which circulated in the fissures, and which, in fact, derived from the beds their dissolved mineral matters. The solvent power of waters holding alkaline carbonates and silicates, and heated to 300° or 360° Centigrade, is probably very great. The questions of the generation of many of these silicates, and of the original composition of the sedimentary rocks, will be discussed further on.

Those who have written on crystalline limestones, and on their mineralogy, have, for the most part, neglected the distinction between the rock and its veins; thus Delesse in his elaborate memoir on the minerals of crystalline limestones, does not even allude to it. Incidentally, however, several observers have noticed the occurrence of various crystallized minerals in veins among the Laurentian limestones of New York and New Jersey. First among these may be mentioned Prof. Charles Upham Shepard, who, in

1832, published a description of the minerals of Orange county, New York (*Amer. Jour. Science* [1], xxi, 321). Prof. H. D. Rogers also, in his Final Report on the Geology of New Jersey, notices the occurrence of aggregates of carbonate of lime, with feldspar, hornblende, pyroxene, sphene, spinel, etc., forming dykes or veins in the crystalline limestone of that region; and shows, moreover, that the franklinite and red zinc ore, with their associated minerals, occur in calcareous veins. Finally, Mr. W. P. Blake, in describing a locality of the first mentioned group of minerals in Vernon, New Jersey, declares it to have the characters of a segregated vein (*Amer. Jour. Science* [2], xiii, 116). Despite these observations, however, Emmons and Mather did not regard the distinction which evidently exists between the bedded limestones and the veins, many of which, from a predominance of carbonate of lime in their composition, became confounded in their eyes with the limestones themselves, leading both of these observers, as we have already seen, to admit the existence of eruptive limestones; while Emmons even concluded that all the limestones of the northern Laurentian district of New York were non-stratified, and of eruptive origin. A careful geognostic study will, however, we think, suffice to show that by far the greater part of the calcareous rocks in the Laurentian system of North America are stratified, and that the so-called eruptive limestones are really calcareous veinstones, or endogenous rocks, generally including foreign minerals, such as pyroxene, scapolite, orthoclase, quartz, etc. These, in other veins, predominate to the exclusion of carbonate of lime, and then present aggregates approaching in composition to the granitic veinstones, into which they pass by the exclusion of calcareous and magnesian minerals, such as calcite, apatite, pyroxene, magnesian mica, scapolite, etc. These species serve to distinguish the veins of the limestone groups from the proper granitic veinstones, in which latter, orthoclase, albite, quartz and muscovite are the characteristic minerals.

The so-called Primitive Gneiss formation of Scandinavia has long been regarded by the Geological Survey as belonging to the Laurentian system (*Esquisse Géologique du Canada*, p. 17; *Geology of Canada*, p. 586), and is associated with crystalline limestones, which have afforded most of the minerals that are to be met with in the Laurentian limestones of North America, together with many additional species. Such of these minerals as are common to the two regions, offer close resemblances, not only in their

characters and associations, but also in the mode of their occurrence. These resemblances were in fact noticed so long ago as 1827 by Dr. William Meade (*Amer. Jour. Science* [1], xii, 303), who called attention to the great similarity between many Scandinavian minerals, particularly from the vicinity of Arendal, and those found in Orange county, New York, and in Sussex county, New Jersey. He instanced, among others, the species pyroxene, chondrodite, scapolite, garnet, sphene and ilmenite. Daubrée, who in 1843 published an instructive account of his examination of the metalliferous deposits of Norway and Sweden, furnishes some interesting details of the minerals associated with the beds of magnetic iron ore in the vicinity of Arendal (*Ann. des Mines* [4], iv, pp. 199, 282). The ore is here found, sometimes in gneiss, and at other times in a gneissoid rock, consisting of various admixtures of pyroxene, hornblende, garnet, epidote and mica, the whole associated with crystalline limestones. These strata are cut by numerous well defined but irregular veins, which are described by Daubrée as granitic or syenitic in character, and have yielded the following minerals: Orthoclase, scapolite, quartz, apatite, lamellar carbonate of lime, hornblende, black mica in large plates, garnet, epidote, allanite, gadolinite, axinite, zircon, sphene, spinel, specular iron, and more rarely, beryl and leucite. Serpentine, chondrodite, lievrite and corundum are also enumerated among the minerals of the district, though not especially mentioned by Daubrée as occurring in the veins. In addition to the species already mentioned, these veins contain datholite and apophyllite, with analcime and various other zeolites, which are, however, possibly of later origin than the other minerals. These veins sometimes include irregular fragments of the wall-rock, and present cavities lined with crystals, showing, not less clearly than the veins which we have mentioned in the Laurentian rocks of Canada, that they have been formed by the progressive filling up of fissures in the strata.

In some instances, these veinstones, by the absence of calcareous and magnesian minerals, become granite-like aggregates of orthoclase and quartz. Daubrée, however, having reference to their structure, calls all of these veins granitic, though they sometimes contain lamellar carbonate of lime. He agrees with Scheerer in supposing them to have been filled by segregation or secretion from the surrounding strata, while Durocher, on the contrary, rejected this view, and supposed them to have been filled by injection.

These veins are seldom of great extent, and near Stockholm, where they are very abundant, rarely exceed 300 feet in length.

At the iron mines in the island of Utoë, where the ore is a mixture of magnetic and specular oxyds, occurring in beds, with hornblendic rocks passing into gneiss, or with crystalline limestone holding hornblende and mica, granitoid veinstones, like those of Arendal, are met with, holding orthoclase and quartz, with tourmaline and oxyd of tin, together with the rare minerals, petalite, spodumene and lepidolite, which occupy the central portion of the veins. This association is the more worthy of notice, as the only other known locality of the rare mineral petalite (if we except the castor of Elba) is in the crystalline limestone of Bolton, Massachusetts, where it occurs with scapolite, hornblende, pyroxene, chrysolite, spinel, apatite and sphene—the characteristic minerals of similar limestones in Canada, New York and Scandinavia.

The occurrence of oxyd of tin in the above associations is not without interest in relation to the economic mineralogy of the Laurentian system, to which the rocks of Utcë probably belong; and it is well to recall, in this connection, the existence of tin ore in rocks, probably of the same age, at Pitkaranta, on Lake Ladoga, in Finland. A rock consisting of greenish lamellar hornblende, with garnet, epidote and pyroxene, is there interstratified with mica-slates, sometimes graphitic, and with a granitic gneiss, the series being cut by granite-like veins. In certain beds of the hornblendic rock, magnetic iron is disseminated to such an extent that the mass becomes an iron ore. This is occasionally associated with oxyd of tin, which in some parts predominates, so that the ore is mined for this metal. Other hornblendic beds in the series are rich in copper pyrites, which is also disseminated in the mica-slates, and is sometimes accompanied by sulphurets of lead, zinc and molybdenum (*Durocher, Ann. des Mines* [4], xv, 316). These associations should not be overlooked in the study of our Laurentian rocks, which may yet be found to be tin-bearing.

Another mineral which may possibly be met with in the Laurentian rocks of Canada is gold, since small quantities of the precious metal are found in several localities in Scandinavia, some of them probably, as that of Barbo, near Arendal, in rocks of Laurentian age. The gold of Scandinavia is, however, in such small quantities as to be nowhere made the object of mining. Details with regard to it are given by Daubrée (*Ann. des Mines* [4], iv, 265) and by Durocher (*Ibid.* [4], xv, 371). Small quantities of

mercury, in the forms of cinnabar and silver-amalgam, are also found associated with galena at Sala in Sweden, in crystalline limestones, probably Laurentian. The notion that gold belongs only to rocks of Lower Silurian age, was many years since disproved by its discovery in the Upper Silurian slates of Eastern Canada, and more recently it has been shown that the great gold mines of California are in strata far more recent, and chiefly of the Jurassic and Triassic periods.

[Since the writing of this report, native gold has been found in the county of Hastings, under several conditions; first, associated with argentiferous fahlerz and with mispickel in small veins of bitter-spar, calcite and quartz cutting magnesian limestones, in Madoc; second, in a quartz vein in Marmora; and thirdly, in small irregular veins cutting magnesian limestone, with ferriferous bitter-spar, black hornblende, quartz and a black coaly matter, in which, as well as in the bitter-spar, the gold is disseminated in plates and crystalline scales. This last locality is also in Madoc, Ontario. See the Report of T. Sterry Hunt and A. Michel on gold in the county of Hastings, 1867.]

The existence of the Laurentian system in Bavaria and Bohemia, as already stated, has lately been established by Gumbel, both by stratigraphical and palæontological evidence. He finds in Bavaria an ancient gneissic series, estimated as not less than 90,000 feet in thickness, and by him divided into a lower portion, chiefly of red or variegated gneiss, which he calls the Bojian gneiss, and an upper portion, distinguished as the Hercynian gneiss. To this succeeds a series consisting chiefly of micaceous schists, with hornblendic and chloritic bands, overlaid by what he calls the Hercynian clay-slate formation, which immediately underlies the primordial zone of the Lower Silurian system. The prevailing character of the Hercynian gneiss is greyish, very quartzose, often containing black magnesian mica, and frequently having an admixture of oligoclase. Great portions of this gneiss are also marked by the presence of iolite or dichroite, giving rise to a distinct variety of rock, the so-called iolite-gneiss or dichroite-gneiss. Beds of hornblende slate, diorite and hornblendic gneiss are also abundant in this series, particularly in the vicinity of the limestone bands, and are often accompanied by beds of metallic sulphurets, and by lenticular masses and beds of graphite, which sometimes impregnates the beds to such an extent as to be wrought with profit. It is in these strata that the well-known plumbago deposits of the



vicinity of Passau are found, under conditions closely similar to those of Canada and New York, in the same geological system. The crystalline limestone band near Passau, which occurs in hornblende gneiss, is from fifty to seventy feet in thickness, and is directly overlaid by a bed of several feet of hornblende slate, between which and the limestone, a bed of three or four feet of serpentine is interposed, and in other parts a layer of nearly compact scapolite, mingled with hornblende and chlorite. The stratified granular limestone beneath contains, among other minerals, serpentine, chondrodite, hornblende, mica, scapolite, garnet and graphite; the disseminated serpentine here, as in Canada, replacing the *Eozoon Canadense*.

The occurrence of iolite, as a frequent element in the Laurentian gneiss of Bavaria, is a fact of interest, inasmuch as it is also one of the minerals of the same ancient gneiss in Scandinavia, and may be looked for in this country, although it has not yet been detected in the undoubted Laurentian rocks of North America.\*

The Hercynian clay-slate series of Bavaria, already referred to, and supposed by Gumbel to correspond to our Huronian series, includes a formation of crystalline limestones more than 300 feet in thickness, containing, like the older limestone of the Laurentian system, graphite, chondrodite, hornblende and serpentine, the latter two minerals replacing a peculiar and distinct species of *Eozoon*, named *Eozoon Bavaricum*.

Allusion has been made to the crystalline limestones which occur in Bolton and the adjoining towns in Eastern Massachusetts, and resemble in geognostic and mineralogical characters those of the Laurentian system. There are, however, not wanting reasons for supposing them to belong to a more recent geologic period, and the facts recently observed in Bavaria, and detailed above, show what was antecedently probable, that similar mineralogical characteristics may be found in crystalline limestones of very different ages.

In this connection, it is not without interest to recall the mineral characters of the rocks of Ceylon, which present many striking resemblances to the Laurentian strata of North America, and may perhaps be found to belong to the same system. The island was,

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\* Iolite, as I have elsewhere remarked, is related to the feldspars, of which it has the atomic volume, and may be looked upon, chemically, as a feldspar, with the oxygen ratios, 5:3:1 (intermediate between labradorite and anorthite, and corresponding to barsowite and bytownite), in which magnesia, sometimes with protoxide of iron takes the place of lime and soda.

so long ago as 1818, described by Dr. John Davy (*Trans. Geol. Soc.*, London, 1st series, v. 311) as made up of old feldspathic gneiss and gneissod limestone, together with granular crystalline limestone and dolomite, both in mountain masses and in veins, the latter sometimes white and lamellar, and enclosing spinel and apatite, prisms of yellow mica, cinnamon-stone garnet, yellow tourmaline and zircon, the latter two minerals associated with feldspar and quartz. The lamellar graphite, so abundant in the island, was regarded by Dr. Davy as the characteristic associate of the gems, spinel, zircon, garnet. etc. Anhydrite exists there in the gneissoid limestone, which he found to be impregnated also with sulphate of magnesia, nitre and nitrate of lime. In addition to these minerals may be mentioned sapphire and chondrodite, which are found together, imbedded in lamellar calcite, in Ceylon, and were mentioned by me in the *Report on the Geology of Canada* for 1847, page 134, as similar to those of our Laurentian rocks.

It is now proposed to consider the minerals of the limestones, with their accompanying beds of pyroxenite, gneiss, etc., which together constitute what we have denominated the limestone groups of the Laurentian system. When the mineral species occur disseminated in the stratified or indigenous rocks, and form an integral part of them, they will be designated as *bed-minerals*, but when, on the contrary, they appear to belong to endogenous masses, occupying fissures or cavities in the strata, they will be spoken of as *vein-minerals*. The study of the species found under these two conditions will show that nearly all the minerals met with in the veins likewise occur disseminated in the strata, and will permit the inference that it is from the latter that the vein-minerals have all been derived. In the case of such as contain the rarer elements, however, it may well be supposed that these are so diffused through the mass of the sediments, that it was only when concentrated in the veinstones that they are capable of being recognized by mineralogical characters. It is nevertheless evident that, in certain cases at least, the particles of the sedimentary strata have at one time possessed a sufficient mobility to permit of crystallization, and of a partial segregation and grouping of their heterogeneous elements.

In the following list are included all the minerals, so far as yet known, which may be regarded as belonging to the Laurentian limestones of North America, and their immediately related strata. In addition to the rocks of this denomination in Canada, and in

northern New York, are to be added those of the Highlands of the Hudson, and their extension in Orange county, New York, and in Sussex county, New Jersey. The observations of Prof. J. Hall and Sir William Logan upon these rocks in the Highlands, have confirmed the views of those who had previously asserted them to be older than the Lower Silurian series, and shown that they are doubtless of Laurentian age. This more southern area is much better known and explored than the comparatively wild and uncultivated Laurentian region of Canada, yet with the exception of the remarkable zinciferous minerals, franklinite, red zinc ore, willemite and dysluite, which are confined to a small section in New Jersey, nearly all the mineral species of these limestones found in the United States have already been recognized in Canada.

#### MINERALS OF THE LAURENTIAN LIMESTONES OF NORTH AMERICA.

Calcite.	Epidote.
Dolomite.	Allanite.
Fluor-spar.	Zircon.
Heavy-spar.	Spinel.
Apatite.	Völknerite.
Serpentine.	Corundum.
Chrysolite.	Quartz.
Chondrodite.	Sphene.
Tephroite.	Warwickite.
Willemite.	Ilmenite.
Wollastonite.	Rutile.
Hornblende.	Magnetite.
Pyroxene.	Hematite.
Babingtonite.	Franklinite.
Pyrallolite,	Zincite.
Talc.	Cubic pyrites.
Gieseeckite.	Magnetic pyrites.
Loganite.	Copper pyrites.
Scapolite.	Mispickite.
Orthoclase.	Fahlerz.
Oligoclase.	Bismuthine.
Phlogopite.	Blende.
Margarite.	Antimony glance.
Clintonite.	Molybdenite.
Tourmaline.	Gold.
Garnet.	Graphite.
Idocrase.	Anthracite.

No one bed or vein probably has ever been found to include all the mineral species of the above list, yet the composition of some of these veinstones is nevertheless very complex, as may be seen by the following examples. The first is from my own observation of the vein on the tenth lot of the fifth range of Grenville, Ontario, which cuts a crystalline limestone holding scales of mica and graphite, and has itself been mined as a source of the latter mineral. The minerals found in this vein are calcite, apatite, serpentine, wollastonite, pyroxene, scapolite, orthoclase, oligoclase, garnet, idocrase, zircon, quartz, sphene and graphite—fourteen species in all. A still larger number has been observed by Mr. W. P. Blake in a single vein, traversing crystalline limestone, in Vernon, Sussex county, New Jersey. He there found calcite, fluor-spar, chondrodite, hornblende, phlogopite, margarite, red spinel, red corundum, zircon, sphene, rutile, ilmenite, pyrites and graphite, to which list he adds “hydrous peroxyd of iron, and hydrous silicates of alumina” (*Amer. Jour. Science* [2], xiii. 116).

These veinstones, as will be seen from numerous examples in the following pages, are found traversing alike the limestones and their various associated strata. In an instructive instance in the Cheever ore-bed at Port Henry, New York, a vein is found in a bed of magnetic iron, of which it includes angular fragments. The veinstone, for specimens of which I am indebted to Prof. Hall, consists of cleavable masses of a greenish triclinic feldspar, pyramidal crystals of quartz with rounded angles, octahedrons of magnetite, a substance resembling allanite, with a specific gravity of 4.09, and a dark green mineral with the cleavage of pyroxene, but having the hardness and specific gravity (2.713) of loganite. All of the elements of this remarkable aggregate with the exception of the magnetite, are in masses of an inch or more in diameter.

**CALCITE.**—In many of the veins traversing the strata of the limestone group, calcite is entirely wanting, or is present only in small portions; but in others it occurs in large quantity, and so far predominates that the veinstone is readily mistaken for a crystalline limestone, generally coarse, but sometimes very fine grained, which is occasionally white, but more frequently yellowish, pink, flesh or salmon colored, and rarely pale blue. These ancient calcareous veinstones are sometimes nearly free from foreign minerals, but more frequently include crystals, often of large dimensions, of

apatite, magnesian mica, pyroxene, brown tourmaline, and other minerals. Drusy cavities, in the veins of mingled calcite and apatite in Burgess, are sometimes lined with large crystals of dog-tooth spar. We have already insisted on page 48 upon the fact, which is there for the first time pointed out, that it is these highly calcareous veinstones which have given rise, in North America at least, to the widely-spread notion of the eruptive origin of crystalline limestones.

Of calcite as a bed-mineral, constituting great stratified masses of limestone in the Laurentian series, it is not necessary here to speak. It is, however, to be remarked that in these limestones, as in those of later periods, we have now evidence that portions of the carbonate of lime once belonged to living organisms, as is shown in the calcareous skeletons of the Eozoon. These, though sometimes preserved by injection with silicates, appear in other cases with their tubes and canals filled with carbonate of lime, evidently—like the silicates—a chemical deposit, and there is no doubt that a part of these limestones, like those of more recent formations, have been directly precipitated by chemical reactions from the waters of the ocean. The often repeated assertion that organic life has built up all the great limestone formations, is based upon a fallacy, for animals have no power to generate carbonate of lime. Although many invertebrate animals construct calcareous skeletons, which form a great part of the limestone of the earth's crust, the pre-existence of this carbonate of lime is one of the conditions necessary to their growth, and, as I have elsewhere shown, owes its origin to chemical reactions which are still going on in the ocean's waters, and which have in past times given rise directly to limestone strata, in which the occurrence of shells and corals is only accidental (*Geol. Can.*, pages 575, 631).

**DOLOMITE.**—As already pointed out in the *Geology of Canada*, pages 24 and 592, large beds of the Laurentian limestones are magnesian, and sometimes have the composition of true dolomites. These dolomites and magnesian limestones have been found to contain serpentine, hornblende (tremolite), apatite, quartz and small portions of mica, and they may, perhaps, in different localities, include all those mineral species which have been indicated as belonging to the limestone strata. It is to be remarked that the calcareous skeleton of *Eozoon Canadense*, which is carbonate of lime, is found, in specimens from Burgess, replaced by dolomite.

The mineral filling the chambers of the fossil is in this case loganite, but the delicate tubuli, which are preserved in the Eozoon from most other localities, have almost entirely disappeared; a fact perhaps connected with the removal of the calcareous skeleton, and its replacement by dolomite.

As a vein-mineral, dolomite has been but seldom observed in the Laurentian veins. A magnesian carbonate of lime is, however, found in two localities in North Burgess, in one case forming the gangue of apatite crystals, and in the other of prisms of brown mica. The analysis of the yellowish sparry carbonate, in the latter instance, showed it to contain, besides carbonates of lime and magnesia, a notable amount of carbonate of iron and a little carbonate of manganese. These complex carbonates require further study. The interesting results obtained by Jenzsch in the analysis of a similar white sparry carbonate, which, at Sparta, New Jersey, forms the veinstone of the red zinc ore and franklinite, deserve to be recalled in this connection. He found the spar to contain carbonate of lime 79.96, carbonate of magnesia 1.94, carbonate of manganese 11.09, carbonate of iron 0.60, carbonate of zinc 0.58, besides 5.39 per cent. of fluorid of calcium, an ingredient which he has also detected in the calcareous spar of several other localities (*Amer. Jour. Science* [2], xxi, 197).

FLUOR SPAR.—Inasmuch as fluorid of calcium enters into the composition both of the calcite and the apatite of these calcareous veins, we are prepared to find it separately crystallized, as fluor-spar, which occurs in several localities among the Laurentian limestones of the United States, in veins with scapolite, chondrodite, pyroxene, spinel, and other characteristic species. In Canada it is met with in Ross, Ontario, in small purple cleavable grains, imbedded, with prisms of apatite and large crystals of spinel, in what has been described in the *Geology of Canada*, pages 461 and 463, as a yellowish white crystalline limestone, and which, from its mineralogical characters, will probably be found to be a veinstone. In addition to this, a small vein, filled with cleavable purple fluor-spar, was observed in the vicinity. The purple fluor which occurs with red heavy-spar, in fissures or cavities in the limestone associated with the hematite of Iron Island, in Lake Nipissing (*Geol. Can.*, pages 456 and 463), is probably also a veinstone mineral, and I know as yet of no certain evidence that fluor occurs as a distinct species among the Laurentian bed-minerals.

**HEAVY-SPAR.**—The heavy-spar found in the Laurentian rocks, generally belongs to the recent or lead-bearing veins, but sometimes appears in the older veins. In addition to that just mentioned as occurring at Iron Island, small quantities of flesh-red lamellar sulphate of barytes are found with quartz, implanted on apatite, in a vein in Burgess.

**APATITE.**—This is one of the most abundant minerals in the Laurentian veinstones, of which it sometimes constitutes the entire mass, appearing, as described on page 761 of the Geology, as a crystalline, homogeneous rock, translucent, with an uneven fracture, a vitreous lustre, and a grayish color, passing into greenish or reddish. It then resembles in its aspect some varieties of quartzite, and at other times consists of incoherent grains, resembling a disintegrating sandstone. Another variety is more coarsely crystalline, sea-green in color, and, like the last, intermixed with a little black mica. In this instance, large and distinct prisms of apatite, with rounded angles, are observed penetrating the confusedly crystalline mass of the same mineral, which has apparently been deposited upon and around them. The locality of this variety is on the twenty-fifth lot of the eighth range of North Elmsley, Ontario (which is described in the Geology as a bed, but is probably a vein). There, adjoining three feet of nearly pure apatite, is found an admixture of crystals of apatite with crystalline flesh-colored carbonate of lime, accompanied by loganite and sphene. In several other localities in this region, outcrops of a precisely similar aggregate are found, which would be described as crystalline limestones, generally reddish or pink in color, and including crystals and irregular crystalline masses of green apatite, sometimes associated with large prisms of magnesian mica. In those places where it has been possible to determine the attitude of these aggregates, it is very evident that they are true veinstones, cutting the bedded rocks of the country. Crystals of apatite several inches in diameter are often met with, and one in the Museum of the Geological Survey is eighteen inches long and twenty-six inches in circumference, and weighs about one hundred pounds. Like all the apatite crystals from this region, its lateral and terminal angles are very much rounded. The apatite crystals of these veinstones are generally of some shade of green; but in Ross, crystals of a reddish-brown color are met with, and others of an

olive-green, passing into wax-yellow, imbedded with purple fluor, in carbonate of lime.

The crystals of apatite from these veinstones sometimes include rounded crystals of quartz, or of carbonate of lime, and on the contrary are sometimes themselves imbedded, not only in carbonate of lime and dolomite, but in massive apatite, in quartz, in mica, or iron pyrites, in foliated graphite, and probably in other minerals. In one case, a crystal of apatite one-fourth of an inch in diameter and two inches long, was found imbedded in a large crystal of mica, one end only projecting from the side of the mica prism, with which the prism of apatite was at right angles. In Ross, crystalline grains of yellow apatite are imbedded in octahedrons of black spinel. As already stated, prisms of apatite, often of large dimensions, line drusy cavities in the veins of massive apatite, or of mingled apatite and pyroxene. In the latter case, large crystals of the two species are sometimes found grouped together like those from Snarum, in Norway. In the specimens from the latter locality, however, unlike those from Burgess, the apatite prisms preserve their sharpness of outline, and, as well as the accompanying pyroxene, are partially incrustated with quartz crystals.

Apatite occurs in the veins in Burgess incrustated with crystals of quartz, sometimes, smoky, ferruginous, or amethystine, and at Ticonderoga, New York, crystals of apatite are imbedded in massive vitreous quartz. The radiated and botryoidal apatite, named eupyrochroite by Emmons, is worthy of notice as a peculiar form of the mineral; it occurs with quartz, brown tourmaline and allanite, filling a vein at Ticonderoga. The mineral from North Burgess, as shown in the *Geology of Canada*, belongs to the variety fluor-apatite, the analysis of a pure massive specimen having given me phosphate of lime 91.20, fluorid of calcium 7.60, chlorid of calcium 0.78, insoluble 0.90 = 100.48.

Apatite as a bed-mineral is very frequent, both in the limestones of the Laurentian system and their associated rocks. Small crystals of it are often disseminated through the limestone beds, generally in very small proportion, but in some cases rising to two or three per cent, or even a much larger amount, though still in the form of grains or small crystals, often with pyroxene. These larger proportions of apatite appear to characterize certain beds or bands in the limestone.

Apatite also occurs disseminated in grains or small masses,



marking the stratification in the beds of the pyroxenite, and in one instance, to be described further on, was observed forming a small interrupted bed in this rock. The magnetic-iron ore, which often forms beds in the immediate vicinity of the limestones of the Laurentian series, and, like the pyroxenite, is to be regarded as belonging to the limestone groups, contains in some places in New York, a large admixture of grains or small prisms of apatite, generally reddish-brown, but sometimes colorless, and occasionally associated with grains of green pyroxene. Specimens of a similar aggregate of magnetite and apatite are said to have been found on the Ottawa; and it is worthy of remark that the extensive beds of iron ore found in Laurentian rocks in Grangjärde in Sweden, and consisting of an admixture of magnetic and specular oxyds, very generally contain grains of apatite, whose presence is supposed to depreciate the quality of the iron there manufactured. (*Durocher, Ann. des Mines* [4], xv, 249).

SERPENTINE.—This species, though not very common in the Laurentian veinstones in Canada, sometimes occurs in small disseminated grains, or in crystals of considerable size, imbedded in calcite. Examples of this occur in North Burgess, where, in one locality, imperfectly defined crystals, an inch in diameter, and in another, small grains, with corundum, sphene, mica and pyroxene, are found; in both cases imbedded in calcite. A massive serpentine also occurs, forming the gangue of large crystals of mica in northern New York. The large crystals of serpentine (sometimes enclosing a nucleus of chrysolite) from Snarum in Norway, which, according to Scheerer, are accompanied with mica, and imbedded in ilmenite, or in magnesite, in the midst of gneiss, probably belong to a vein. Crystals resembling them occur in New York (*Amer. Jour. Science* [2], xvi.)

Distinct from these veins are the small seams filled with fibrous serpentine or chrysotile, which are frequently found traversing the massive serpentines, or the mixtures of serpentine and limestone which make up great beds in the Laurentian series. Massive translucent serpentine often occurs as the mineral replacing the *Eozoon Canadense*, the canals of which are in such cases injected with this silicate. In some cases the unbroken calcareous skeleton of the fossil is preserved in the serpentine, while in others, only broken and detached fragments of the skeleton are found, sparsely distributed through the serpentine. The presence of dis-

seminated grains of serpentine, in greater or less abundance, characterizes beds, both of pure limestone and of dolomite, in the Laurentian series; and beds of pure, or nearly pure, serpentine are also met with, sometimes enclosing scales of mica, grains of calcite, which, under the microscope, are seen to be fragments of Eozoon, or finely disseminated peroxyd of iron, which gives to the serpentine a deep red color. Concretionary masses of serpentine, sometimes exhibiting in the arrangement of different colors a banded or agatized structure, are often met with, imbedded in the limestones, and generally have a nucleus of white granular pyroxene. These masses may vary from a few inches to a foot or more in diameter.

I have already elsewhere described the composition of the Laurentian serpentines, their low specific gravity and pale colors—characters which are due to the small amount of oxyd of iron, and the large proportion of water (equal to about fifteen per cent) which enters into their composition. These characters, together with that of the constant absence from them of chrome and nickel, serve to distinguish the Laurentian serpentines of North America from most others known, and to connect them with those from the old rocks of Scandinavia, with which they have a close resemblance.

An analysis of the chrysotile from a narrow vein traversing the Eozoon rock of Petite Nation seigniory, Quebec, gave me, silica, 43.65; magnesia, 41.57; protoxyd of iron, 1.46; water, 13.48=100.16.

**CHRYSLITE.**—This species, which is found in the crystalline limestones of Somma, and, according to Rose, occurs with the serpentines of Snarum, is known in the crystalline limestones of Bolton, Massachusetts, under the name of boltonite, which Messrs. Lawrence Smith and Brush have shown to be a pure magnesia-chrysolite. I place it in the list of Laurentian minerals, on the authority of Messrs. Horton and Beck, according to whom, boltonite occurs in several localities in limestone, associated with spinel and hornblende, in Orange county, New York (*Beck, Mineralogy of New York*, page 283). It is not improbable that this mineral may be more widely diffused, and it has perhaps been confounded with chondrodite, like which species, and like serpentine, it will probably occur both in beds and in veinstones.

**CHONDRODITE.**—This fluosilicate of magnesia occurs in calcareous veins, generally with spinel, in numerous localities in the United

States, but I have as yet noticed it in Canada only in beds, where disseminated grains of chondrodite mark the places of stratification in the limestone. In one instance, in a specimen of limestone from an unknown locality, the contact of two layers, one marked by grains of chondrodite, and the other by grains of serpentine, is distinctly seen. A similar association of the two minerals occurs at St. Jérôme, in the province of Quebec.

**TEPHROITE, WILLEMITE.**—These two rare species, the first a silicate of manganese, and the second a silicate of zinc, both of them having the general formula of chrysolite, with which the former is isomorphous, have hitherto only been observed in North America, in Laurentian veins, crystallized with the franklinite and red zinc ore of Sterling, New Jersey, and its vicinity.

**WOLLASTONITE.**—This species forms considerable masses in the large vein already noticed in Grenville, where its associates in the veinstone are pyroxene, orthoclase, quartz, apatite and sphene. In smaller specimens it occurs with the same associates in a vein in North Elmsley, while in Willsborough, New York, it is found also in a vein with grains of green pyroxene, and red granular garnet, which latter in some part predominates to the exclusion of the other minerals.

As a bed-mineral I have observed it in North Burgess, sparsely disseminated in a limestone, with small quantities of green pyroxene, brown mica and apatite. In the same vicinity, interstratified with pyroxenite, are interrupted beds of rock made up of quartz and wollastonite. Similar associations to these occur elsewhere in the Laurentian strata.

**HORNBLENDE.**—The hornblende of the Laurentian limestones is either in the form of tremolite, or more frequently in green prismatic crystals belonging to the variety called pargasite. The raphilite, a grayish fibrous hornblende, allied to tremolite, occurs apparently in a vein with quartz, mica, apatite and calcite. Large well-defined crystals of dark green pargasite are found implanted upon or imbedded in still larger crystals of pale-green pyroxene, in a vein described by Sir William Logan as occurring near the High Falls on the Madawaska, Ontario, cutting across alternating strata of gneiss and limestone, and having a breadth of not less than one hundred and fifty feet. The minerals filling this immense vein are chiefly a pale grayish-green pyroxene (sahlite), pargasite,

calcite, quartz, mica and black tourmaline, the crystals of the first named mineral being sometimes six inches thick, and as much as twenty-four inches in length, and those of the dark green hornblende occasionally an inch both in length and breadth. (See *Geol. Can.*, pages 35 and 466). This association of pyroxene and hornblende has been observed elsewhere in the Laurentian rocks (page 49). Pargasite is frequently found in the apatite veins in Burgess, and sometimes forms the selvage of the vein where this cuts a hornblendic gneiss. Although this species frequently occurs in the gneissoid rocks near the crystalline limestones, it is less frequent, as a disseminated mineral in the limestones, than pyroxene. In the stratified pyroxenite rocks, small portions of hornblende, recognizable by their different crystallization and their darker green color, are not unfrequent. In some localities it appears to take the place of the pyroxene, and large beds of hornblende rock, passing into diorite and hornblendic gneiss, are met with. A radiated green hornblende, actinolite, is sometimes found imbedded in the magnetic iron ores.

**PYROXENE.**—Repeated mention has already been made of the important rank which this species assumes in the Laurentian vein-stones, in which the varieties diopside, sahlite or coccolite often form the predominant mineral. Its crystals are sometimes found, either alone or with mica, imbedded in calcite, or in contact with hornblende, wollastonite, orthoclase, scapolite, garnet, apatite, spinel, zircon or sphene. It often assumes a granular form, constituting what is called coccolite. A white aluminous diopside is found with apatite, giesseckite, etc., in Bathurst, Ontario (*Geol. Can.*, page 467), and the hudsonite of Orange county, New York, is a black aluminous pyroxene.

We have already mentioned the pyroxenite rocks, sometimes micaceous, and at other times mixed with hornblende, or with orthoclase, quartz and sphene. Pyroxene also sometimes occurs disseminated in the beds of magnetite, and grains or imperfect crystals of it, generally of a green color more or less deep, are common in the beds of limestone, and are also sometimes found in the associated quartzites. A pure white granular pyroxene occurs, replacing, like serpentine, *Eozoon Canadense*. Large masses of a similar pyroxene are also frequent in these limestones, generally associated with serpentine, which often incrusts it, and small nuclei of this pyroxene frequently form the centre of concretionary masses of serpentine.

**BABINGTONITE.**—This rare species, which belongs to the pyroxene group, is said to be found upon crystals of feldspar in Gouverneur, New York, and occurs under similar conditions in veins near Arendal in Norway.

**PYRALLOLITE.**—This species, the *rensellærite* of Emmons, occurs in one locality in radiating columnar masses, with quartz, in a vein, and is also met with in beds, in contact with serpentine, with pyroxenite, and in another case with limestone, and enclosing scales of mica and of graphite (*Geol. Can.*, page 470). A compact earthy hydrous silicate of magnesia, having the characters of meerschaum or aphrodite, and the composition of the latter, occurs in cavities in massive *rensellærite* in Grenville (*Ibid.* page 473).

**TALC.**—This species is closely related to the last, and the two may be looked upon as dimorphous conditions of the same hydrous silicate of magnesia. In the Laurentian series, talc seems to be generally replaced by pyralloite, but in one instance is observed mixed with carbonates of lime and magnesia, in such proportions as to give rise to a bed of impure steatite (*Ibid.* page 469). Prof. H. D. Rogers has also indicated talc as occurring in a vein, with calcite, pyroxene and spinel, in Sparta, New Jersey.

**GIESECKITE.**—This mineral, which the careful researches of Prof. G. J. Brush have shown to be identical with the rock named *dyssyntribite* by Prof. C. U. Shepard, and with what I formerly described as *parophite*, is found in large crystals in northern New York, associated with calcite, brown pyroxene and mica, the aggregate doubtless constituting a veinstone. *Wilsonite*, which, notwithstanding its apparently distinct cleavage-form, I have provisionally included under the head of *gieseckite*, with which it is almost identical in composition, hardness and gravity, occurs also in a veinstone, in Bathurst, with calcite, apatite, white aluminous pyroxene and serpentine. The mineral which I once described by the name of *algerite*, is found in white calcite, among the Laurentian limestones of Franklin, New Jersey, and has a composition similar to that of *gieseckite*, although the form of the crystals appears to be a square prism. Whatever conclusions may eventually be arrived at relative to these hydrous silicates of alumina and potash, the assumption that they are results of a supposed alteration of nepheline, scapolite, etc., is purely gratuitous.

The occurrence of beds of this compound, more or less pure (dyssyntribite and parophite), as a massive or schistose rock, alike in the Laurentian and Silurian series, leads us to assign to it a rank and an origin among such rocks as serpentine, steatite, pyroxene, chlorite, glauconite and epidote, all of which silicates, and many others, have been in most cases deposited as aqueous sediments generated by chemical reactions at the earth's surface, and in many cases subsequently modified by crystallization, or molecular re-arrangement (*Geol. Can.*, page 581.)

As I have elsewhere remarked, although sparry in structure, gieseckite and wilsonite have very nearly the chemical composition of the hydrous potash-mica, margarodite. In like manner the sparry silicates, pyrallolite and loganite, correspond to the foliated species, talc and pyrosclerite, of which they have the elementary composition, although differing entirely in structure (*Ibid.* page 492).

LOGANITE.—This prismatic hydrous species, which I first described in 1848, has recently acquired a new interest. It occurs in several places as a veinstone, in one case filling the central portion of a vein of apatite, and inclosing calcite and sphene; and in another, in considerable masses, with large crystals of mica, imbedded in a great vein of pyroxene. Evidence of its occurrence as a sedimentary mineral is afforded by the fact that in one locality it forms the enclosing and filling material of the Eozoon.

[This species, numerous analyses of which will be found in the *Geology of Canada*, page 491, has been by Dana (*Mineralogy*, 4th edition) referred to pyrosclerite, which he however described as possessing an eminent basal cleavage, and in fact identical with the foliated micaceous minerals kaemmererite and vermiculite. I have maintained the distinctness of loganite from these, first, from the greater amount of water in its composition, and, secondly, from the entire absence of foliated or micaceous structure. Specimens declared to be the original pyrosclerite from Elba, which I have since examined, have, however, a sparry aspect, and a cleavage resembling that of pyroxene and loganite. The difference in composition between loganite and pyrosclerite still remains to be got over; but if these two minerals are to be identified, neither of them can be confounded with kaemmererite or vermiculite, from which they differ as pyrallolite does from talc.]

In the *Geology of Canada*, page 490, attention has been called

to several other hydrous aluminomagnesian silicates approaching to loganite in composition, and resembling serpentine or pyralolite in sensible characters. Two of these, described and analyzed by Dr. Beck, occur in the Laurentian limestones of Orange county, New York. These form altogether an interesting and but little understood group of minerals, which are perhaps most important in the history of the crystalline limestones than has hitherto been supposed.

**ORTHOCLASE.**—This species is common in Laurentian limestones, generally with pyroxene and sphene, and sometimes accompanied by scapolite or a triclinic feldspar. The orthoclase of the veins is, as I have shown, sometimes a very pure potash-feldspar, while the variety named loxoclase by Breithaupt, which occurs with pyroxene in a Laurentian vein in Hammond, New York, was found by Smith and Brush to have a predominance of soda (*Geol. Can.*, p. 475). Large isolated crystals of white orthoclase are found, with spinal, apatite and fluor, in a veinstone of lamellar pink carbonate of lime in Ross. The perthite of Burgess, which probably belongs to a granitic veinstone, is also an example of an orthoclase with a large amount of soda.\* An orthoclase, reddish-brown in color, like the perthite, but without its aventurine-like reflections, also occurs in Burgess, mixed with a little quartz, and sometimes with green apatite, in the midst of a large vein chiefly of apatite and calcite, forming a granite-like vertical layer, equidistant from the two walls of the vein. Orthoclase is sometimes disseminated in the beds of pyroxenite which accompany the Laurentian limestones, and are in that case interstratified with beds of an aggregate of orthoclase and quartz, forming a granitic gneiss, into which the pyroxenite graduates.

**OLIGOCLASE.**—To this species I refer provisionally, a white translucent triclinic feldspar, which occurs in small masses with orthoclase, pyroxene and sphene in a vein at Grenville, already noticed. A similar white feldspar, recognizable by the beautiful striation of its cleavage planes, occurs with pyroxene and sphene in Willsborough, New York, and a dark green triclinic feldspar is found with apatite, pyrites and magnetite near Dover, New Jersey, and with magnetite and allanite at Port Henry, New York. None

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\* It has since been shown by Gerhard to be made up of thin layers of reddish orthoclase and whitish albite. See *Dana's Mineralogy*, fifth edition, page 356.

of these, so far as I am aware, have been analysed. The peristerite of Thompson, which, as I have shown, is an opalescent albite, containing, however, a small portion of lime, belongs to a Laurentian veinstone, and is accompanied by quartz and orthoclase.

Portions of a feldspar are occasionally intermixed with the pyroxenic and hornblendic strata accompanying the Laurentian limestones. This in some cases is orthoclase, as remarked above, but at other times is evidently a triclinic species, giving rise by its admixture with hornblende to a kind of diorite. The great beds of rock, composed chiefly of labradorite or related triclinic feldspars, which have been elsewhere described as belonging to the Laurentian system, occur in that upper and unconformable division which has been designated as the Upper Laurentian or the Labrador series.

**SCAPOLITE.**—Under the head of scapolite and its various synonyms, mineralogists have included a number of dimetric silicates allied to the feldspars, and sustaining to one another relations similar to those of the different triclinic feldspars; the extremes being dipyre, the least basic, and meionite, the most basic of the series. Scapolite abounds in many of the Laurentian veinstones, often associated with pyroxene or sphene (sometimes with orthoclase), and frequently in detached crystals, imbedded in calcite. It will not improbably be found in the crystalline aggregates which make up some of the stratified rocks of the series, and has been observed by Gumbel under such conditions in Bavaria. See pages 47 and 67.

**PHLOGOPITE.**—The crystallized mica of the Laurentian calcareous veinstones is a magnesian mica, and belongs to the species phlogopite or biotite. The crystals, which occasionally afford laminae two feet square, are found imbedded alike in calcite, dolomite, apatite, serpentine and pyroxene. Packed close together, with but little intervening matter, large crystals of magnesian mica sometimes line the walls of veins whose centre is filled with apatite. The laminae of the large mica crystals are often contorted, and sometimes hold between them thin plates of calcite or quartz, or flakes of plumbago. In one case already noticed, a well-formed crystal of apatite was found imbedded in a prism of mica, which had evidently crystallized around it. Some of the finest crystals of mica of moderate size occur imbedded in serpentine, or with crystallized pyroxene, in calcite.



Small plates of mica, probably a magnesian species, abound both in the limestone beds and the pyroxenites, and sometimes form layers of a schistose mica-rock, interstratified with the latter. Non-magnesian micas, belonging to the species muscovite, margarodite or lepidolite, are occasionally found in the quartzo-feldspathic veins of the Laurentian series, where compounds of lime and magnesia are wanting; but it is not certain whether they ever occur with the calcareous veins or beds. As already remarked, the chemical composition of giesseckite, and of the minerals which we have provisionally associated with it (wilsonite, algerite and dyssyntribite) is identical with the hydrous mica, margarodite, which is thus represented in the Laurentian series by these sparry silicates, precisely as talc is there represented by pyralloite (*Geol. Can.*, pages 482-486 and 492).

**MARGARITE.**—This species, the emerylite of Dr. J. Lawrence Smith, which may be regarded as a hydrous lime-mica, is mentioned by Blake as occurring with corundum, spinel and calcite in a Laurentian veinstone in Vernon, New Jersey, but has not been elsewhere identified.

**CLINTONITE.**—This mineral, somewhat related in composition to the preceding species, occurs in several localities in Orange county, New York, with spinel and chondrodite, in calcareous veinstones. It has also been observed, with small crystals of blue spinel, in a calcareous matrix, in Daillebout, Quebec.

**TOURMALINE.**—This species frequently occurs in the calcareous Laurentian veins, with pyroxene, hornblende, apatite and calcite. The finest crystals of brown tourmaline in Canada have been found in veinstones of flesh-colored calcite, either with or without pale green pyroxene, or in a veinstone of translucent quartz. Black tourmaline is also occasionally found with pyroxene, but is more generally met with in the granitic veinstones, with orthoclase and a non-magnesian mica. Tourmaline, in grains or imperfect crystals, also occurs in the stratified rocks of the series. In one instance it appears in small knot-like masses, in an impure grayish limestone, apparently marking the planes of stratification.

**GARNET.**—This mineral frequently occurs in the veins, sometimes imbedded in orthoclase or in quartz, at others in calcite, or, as at Willsborough, New York, forms granular masses, associated

with wollastonite and pyroxene. Garnet is moreover of frequent occurrence in the strata associated with the limestones, sometimes disseminated in grains in the pyroxenites, and more often in accompanying beds of quartzite, in which it sometimes forms layers of red garnet rock. The strata of gneiss in the vicinity of the limestones often abound in garnet.

**IDOCRASE.**—This species, although less abundant than garnet, is found in several places associated with it. The occurrence in a vein of a skeleton-crystal of yellow idocrase, enclosing orthoclase and zircon, has been noticed on page 50. The same vein affords crystals of cinnamon-stone garnet. I have elsewhere described a boulder of crystalline carbonate of lime, apparently a veinstone, found on the Ottawa, in which were detected small square prisms of idocrase, dodecahedrons of garnet, and terminated triangular prisms of tourmaline, all three species being of a bright yellowish-brown color.

**EPIDOTE.**—This species occurs in several localities in calcareous veins among the Laurentian rocks in New York and New Jersey, sometimes crystallized with orthoclase, pyroxene and graphite, or as described by Prof. Henry Wurtz, imbedded in fine crystals in calcite, in Byram, New Jersey. A specimen from Cold Spring, New York, exhibits a crust of small crystals of epidote coating a large prism of pyroxene. Although not hitherto detected in any of the Laurentian veins in Canada, epidote enters largely into the composition of the pyroxenic and feldspathic rocks which are associated with the limestones in the vicinity of the iron ores of Belmont and Seymour, Ontario.

**ALLANITE**, which is regarded as a cerium-epidote, occurs in some of the Laurentian veins, associated with apatite and tourmaline at Ticonderoga, and with quartz, feldspar and magnetite at Port Henry, New York.

**ZIRCON.**—This species is of frequent occurrence in the calcareous veins, associated with pyroxene, hornblende, orthoclase, scapolite and sphene. In Munroe, Orange county, New York, crystals of zircon abound in a gangue of magnetic iron ore with pyroxene and feldspar, and according to Durocher, zircon is also met with in the magnetic iron of Solberg, near Arendal, and at Langsoë in Norway (*Ann. des Mines* [4], xv, 229). Zircon is also found disseminated in

large proportion in a gangue of black hornblende with a little feldspar, in Cornwall, Orange county. Large and well-defined prisms of zircon, which occur with apatite and feldspar in Hammond, St. Lawrence county, New York, are sometimes, like the idocrase noted above, skeleton crystals, filled with carbonate of lime (*Beck, Mineralogy of New York*, page 381).

**SPINEL.**—This mineral is often abundant in the calcareous Laurentian veins, generally associated with chondrodite, pyroxene, clintonite, serpentine, ilmenite, and other species. Sometimes it is imbedded in calcite without any other mineral, as in Burgess, where a mass of pink limestone, probably a veinstone, has afforded fine crystals of black spinel an inch in diameter. In Ross, similar crystals occur in a calcite vein with orthoclase, fluor-spar and apatite; grains of the latter mineral are frequently imbedded in the spinel crystals. Small crystals of spinel are sometimes found disseminated in what appear to be stratified limestones. Although the spinel of the Laurentian limestones is generally black, blue, red and green varieties are occasionally met with. The dysluite or zinciferous spinel is worthy of notice, as occurring in Stirling, New Jersey, with other zinc-bearing minerals.

**VÖLKNERITE.**—To this species, a hydrous aluminate of magnesia, Dana has referred the houghite of Shepard, from St. Lawrence county, New York, which occurs associated with crystals of spinel, and having the same octahedral form, but distinguished by a low specific gravity, and a softness like steatite. A gradation is seen from the hard spinels to the houghite crystals, which still include a portion of spinel, but consist chiefly of a matter having the composition of völknerite. It would seem that the crystallogenic force of the spinel has given its form to accompanying völknerite. Small steatitic octahedrons, apparently similar to the houghite, have been found imbedded in serpentine, in Burgess, but require farther examination. The hydrotalcite, which is regarded as identical with völknerite, occurs with ilmenite in the Laurentian serpentine of Snarum, in Norway.

**CORUNDUM.**—Crystallized corundum, white, blue or red in color, occurs with associations similar to those of spinel, which occasionally accompanies it. Crystals of corundum line cavities in the large spinels from Orange county, New York. The red crystals from Vernon, New Jersey, as described by Blake, like the idocrase [Senate No. 92.]

and zircon mentioned above, often present a mere outer shell of corundum filled up with other minerals. The corundum found in Canada is imbedded in calcite with pyroxene, sphene and mica, and very closely resembling those associated with it at Vernon.

**QUARTZ.**—The presence of crystalline quartz in the Laurentian veinstones has already been repeatedly noticed. Sometimes, as at Gouverneur, New York, it is found in crystals with rounded angles imbedded in crystalline calcite ; at other times implanted on apatite, as in Burgess, where the crystals are occasionally amethystine, smoke-brown or opaque-red in color, and unlike the apatite, to which they are posterior, have not their angles rounded. Quartz is of very common occurrence in the veins, mingled with wollastonite, pyroxene or orthoclase, and a vitreous quartz is sometimes the gangue of crystallized brown tourmaline and of apatite. It is also frequently disseminated in grains or small masses in the limestone beds, or forms in the accompanying strata layers, in which it is sometimes mingled with wollastonite, with green pyroxene, with garnet, or with orthoclase. Besides these, thin layers and massive beds of quartzite are frequent, and are often interstratified with the limestones.

**SPHENE.**—This is one of the most common minerals of the calcareous Laurentian veins, and its occurrence and associations have already been repeatedly mentioned. It also occurs in small grains or crystals, generally olive-brown in color, disseminated in the stratified limestones, or more frequently in the associated pyroxenic and feldspathic strata.

**RUTILE—ILMENITE.**—Both of these species are occasionally found crystallized in Laurentian veins with spinel, chondrodite, corundum, etc., or imbedded in serpentine. The imbedded grains and masses of ilmenite, often of great size, and sometimes intermixed with rutile, which occur at Bay St. Paul, Château Richer, and elsewhere in the province of Quebec, appear to belong to the Upper Laurentian or Labrador series, and neither of these minerals have as yet been met with in the proper Laurentian rocks in Canada, although occurring in several localities in New York. The ilmenite crystals, with serpentine, from Snarum, and with hornblende and calcite from Krageroë, are well known to mineralogists.

**MAGNETITE.**—This important iron ore, which constitutes one of the principal sources of mineral wealth to the Laurentian regions

both of North America and of Scandinavia, has been shown by the explorations of the Geological survey in Canada to occur in great beds, interstratified with the limestones of the series or in their vicinity. This is clearly the case with all the considerable deposits of ore hitherto examined in Canada; yet, as in the case of the crystalline limestones, there are those who maintain the eruptive character and igneous origin of these masses of ore. Emmons looked upon the magnetic iron ores of northern New York as intrusive masses, and Prof. H. D. Rogers in like manner regarded the magnetic iron ores of the Laurentian strata of New Jersey not as beds, but as real veins of injection (*Final Report, Geol. N. Jersey*, page 22). Durocher in like manner, in describing the deposit of the same ore at Bisberg in Sweden, speaks of it as a "plutonic rock" injected among the beds of gneiss in the plane of stratification, and having a thickness of from eighty to one hundred feet. He elsewhere speaks of the injection of the masses of a similar ore near Arendal (*Ann. des Mines*, [4], xv, pp. 203, 204, 225). A careful study of his descriptions and plans will, however, we think, show that these great deposits of Scandinavia are, like the similar masses of ore in Canada and the United States, interstratified sedimentary layers. At the same time there exists in favor of the view maintained by Emmons, Rogers, Durocher, and other geologists, evidence similar to that adduced in favor of the eruptive origin of crystalline limestones; that is to say, the fact of veinstones consisting wholly or in part of magnetic oxyd of iron, An interesting example of this occurs near Dover, New Jersey, where large crystals of apatite occur in a gangue composed of triclinic feldspar and iron pyrites, imbedded in which latter occurs crystalline magnetite in rounded masses, sometimes half an inch in diameter, that were at first taken for ilmenite. Similar associations have been observed in other veins, and it is not improbable that the mixture of magnetite with a large proportion of zircon, described under the head of this species, may be from a veinstone. Another and an instructive instance is that described by Sir William Logan as occurring in the township of Ross, opposite Portage du Fort. Here a vein, or rather a group of reticulating veins and cracks, is seen in a white granular Laurentian limestone, cutting across the stratification, and sending off branches on either side in the plane of the limestone beds. These veins vary from a sixteenth of an inch to two or three inches in thickness, and are filled with highly crystalline magnetite, which in contact with the

limestone presents in some parts large cubic and cubo-octahedral crystals. Two large veins, made up almost entirely of orthoclase and highly crystalline magnetite, each mineral often presenting cleavage planes of a square inch or more, have recently been met with in Buckingham, on the Ottawa. In these veins which intersect the gneiss, and have a breadth of nearly eighty feet each, the magnetite forms more than one-half the weight of the vein-stone. Other and perhaps larger veins of magnetite may exist, and may have given countenance to the theory of its eruptive origin, but it is probable that few of the workable deposits of this ore are of the nature of veins. They appear to be conformable to the stratification, and are cut by the same veins which traverse the adjacent gneiss and limestone. Moreover, they are impregnated with the same minerals as the accompanying strata; grains of apatite, scales of graphite, calcite, feldspar, pyroxene and garnet are occasionally found disseminated in the ore, which, by a predominance of some of these mixtures, passes into the accompanying gneiss, or into hornblendic or pyroxenic rock.

HEMATITE.—Among the Laurentian rocks of St. Lawrence and Jefferson counties, New York, several localities of crystallized red hematite, or specular iron, with brown spar and dodecahedral quartz, are met with, according to Beck, in small veins. In like manner, in the township of Bristol, on the Lac des Chats, specular iron, in broad crystalline plates, occurs with quartz, and also with calcite, in what appear to be true veins cutting the crystalline limestone and the adjoining gneiss. The octahedral peroxyd of iron, martite, which I described several years since as occurring with green hornblende, orthoclase and quartz, from Munroe, New York, is probably from a vein-stone (*Amer. Jour. Science* [2], xiii, 372).

The workable deposits of the granular and compact varieties of hematite, which constitute the red iron ores of Northern New York and of Canada, appear, however, to be in all cases of the nature of beds, and the remarks with regard to the relation of the magnetic ores to the stratification are equally applicable to the present species. Although the great deposits of iron ores in the Laurentian rocks are chiefly of the magnetic species, beds of red hematite have been described as occurring in MacNab, on Iron Island, in Lake Nipissing, and elsewhere. In the Laurentian region of northern New York, in like manner the magnetic oxyd is the prevailing ore, especially in the eastern portion,

while in St. Lawrence county the red hematite predominates, and forms very extensive deposits. In Beverley and in Bastard, Ontario, small beds of this ore occur in the Potsdam sandstone, which there rests directly on the Laurentian; and some of the other deposits of red hematite, already alluded to, may perhaps be found to rest upon this ancient system instead of forming part of it.

The magnetic and hematitic iron ores are sometimes intimately associated both in Scandinavia and in Canada. A specimen now before me from the great magnetic ore bed in Hull, Quebec, consists of two parallel layers, each about an inch thick, the one of coarsely granular magnetite, and the other of compact red hematite, not at all magnetic, the two being somewhat intermingled for half an inch at the junction. Grains of greenish feldspar are disseminated in the magnetite, and both it and the hematite contain imbedded crystalline plates of graphite a tenth of an inch or more in diameter. A film of scaly graphite, moreover, coats the free surface of the hematite layer.

**FRANKLINITE, ZINCITE.**—The two remarkable ores, which are found together in Sterling and Franklin, New Jersey, were long since described by Prof. H. D. Rogers as occurring in veins which traverse the crystalline limestone of the region (*Final Report, Geol. N. Jersey*, 1840, pages 63, 64 and 69–71). The red oxyd or zincite sometimes forms the gangue of the franklinite; at other times the two ores are associated in a matrix of calcite, whose peculiar composition has already been noticed under its proper head. The silicate of zinc, willemite, is also occasionally found with the franklinite in the calcareous veinstone. It remains to be seen whether these ores do not, like the magnetite, occur in the stratified rocks of the region. These zinciferous minerals appear to be confined to a small area in New Jersey, as they have never yet been seen elsewhere in the Laurentian rocks of North America or of Scandinavia. They are sometimes accompanied by colorless transparent blende.

**IRON PYRITES.**—Cubic iron pyrites is of not unfrequent occurrence in the calcareous Laurentian veins, sometimes in distinct crystals, imbedded in calcite, and at other times filling up considerable portions of the veins, as in some localities in Burgess, and associated with apatite, pyroxene or mica. In an instance

mentioned above, a massive pyrites is the gangue both of crystals of apatite and of magnetite. The pyrites from veins in the Laurentian rocks occasionally contains cobalt and nickel, sometimes in large proportions. A bronze colored, compact, impalpable variety, found in irregular reniform or globular masses, with copper pyrites, in North Burgess, gave me on analysis 3.47 per cent of cobalt and 2.21 per cent of nickel. It contained no arsenic.

It would seem scarcely necessary to mention the existence, in the strata, of a mineral so generally diffused as pyrites, were it not for two reasons: first, to recall that pyrites is sometimes disseminated in the beds of magnetic oxyd, so as to render the roasting of these, to remove the sulphur, a necessary preliminary to the smelting process; and second, to remark that the bands in the Laurentian gneiss are sometimes impregnated with pyrites to such an extent that their weathered surfaces become stained of a reddish hue from its decomposition. These iron-stained strata constitute what the German miners call *fahlbands*, and are often of economic interest, from containing ores of more precious metals, such as copper, zinc, cobalt, nickel or even gold and silver, either impregnating certain layers, or accumulated in veins, which intersect the fahlband. From a certain similarity in their chemical relations between all these metals, it happens that their sulphurets are very commonly associated in nature, so that a deposit of pyrites is not unfrequently impregnated with or accompanied by the sulphurets of more valuable metals.

MAGNETIC PYRITES is occasionally found in the Laurentian veins under conditions similar to those just mentioned for cubic pyrites. Near Portneuf, Quebec, a veinstone of calcite encloses small crystals of green pyroxene, together with considerable masses and imperfect crystals of magnetic pyrites.

COPPER PYRITES.—This ore is occasionally found with the Laurentian limestones both in Canada and in New York (*Geol. Can.*, page 692). In some cases it occurs in small irregular veins, with calcite, and occasionally with iron pyrites rich in cobalt and nickel, but unaccompanied by the minerals which generally characterize the Laurentian veinstones. In Escott, Ontario, however, it is found in considerable quantity, in a true granitic veinstone, with orthoclase, quartz, black tourmaline and mica. In the same township there was wrought a deposit of this ore, having apparently



the form of a small lenticular bed, in immediate contact with a bed of magnetic iron ore (*Ibid*, page 693). Small veins filled with cubic and magnetic iron pyrites, copper pyrites and blende, with a little calcite, are found traversing a magnesian limestone in Madoc.

[In another locality in the same township similar veins, having a gangue of mixed calcite, bitter-spar and quartz, carry besides copper pyrites, galena and the two species of iron pyrites just mentioned, mispickel and argentiferous *fahlerz*, the latter species predominating and being associated with a little gold. The *mispickel* of the locality just described contains a trace of cobalt. The same mineral is found in several other localities in that vicinity, which moreover affords *sulphuret of antimony* in small quantities disseminated in dolomite, and in one instance associated with tremolite.]

[BISMUTHINE.—The sulphuret of bismuth is found in crystalline masses of considerable size in a vein cutting a plumbaginous limestone in Lake, in the province of Ontario. It is imbedded in quartz, and immediately associated with plumbago and brown tourmaline, delicate prisms of which are occasionally found penetrating the bismuthine. Minute portions of native bismuth are occasionally met with in the vein, and carbonate of bismuth, probably from the decomposition of the sulphuret, occurs near the surface. This vein belongs to the third class, already described, and in some parts by an admixture of mica and calcite passes into an aggregate which might be mistaken for a coarsely crystalline limestone. These calcareous portions of the vein are pinkish in color, with yellow phlogopite, and contain crystalline masses of iron pyrites.]

SULPHURET OF MOLYBDENUM.—This species, as mentioned in the *Geology of Canada*, pages 503 and 754, occurs in several localities in the Laurentian rocks. In the vicinity of Balsam Lake it is found in small quantities, associated with scapolite, pyroxene and iron pyrites, in a huge vein of quartz which traverses the crystalline limestones of that region.

[GOLD.—The occurrence of native gold has already been mentioned on page 66. Small portions of the precious metal have also been detected in assays of pyritiferous quartz from Belmont, and it is said in quartz from other localities, and also associated

with beds of silicious rock impregnated with plumbago from more than one locality.]

GRAPHITE OR PLUMBAGO.—This mineral is occasionally met with in most of the stratified rocks of the Laurentian system ; not only the limestones, but the gneiss, pyroxenite, quartzite and pyralloite beds sometimes hold disseminated graphite. It is moreover met with in the iron ores of the series, as in Hull, Quebec, where large scales of graphite are imbedded in the crystalline magnetite, and also in Franklin, New Jersey, where, according to Dr. Fowler, the graphite disseminated in the magnetic iron ore is an obstacle to the working of it in the forge (*Rogers, Final Rep. Geol. New Jersey*, page 64). Beck has also described, as occurring near the Natural Bridge, in Lewis county, New York, a mixture of chlorite, graphite and red iron ore, the latter amounting to about one-half of the mass (*Mineralogy of New York*, page 26). The presence of graphite in the hematite which is associated with magnetite in Hull, has already been noticed above. It is, however, chiefly in the limestones that we find graphite disseminated, sometimes so finely divided as to give a bluish-grey tint to certain bands marking the stratification, and at other times appearing in thin detached films or flakes, also marking the stratification. Portions of the rock in this way sometimes become highly charged with graphite, and may form workable beds, but it is doubtful whether accumulations of pure crystalline graphite ever occur in the stratification.

Specimens of an impure amorphous graphite have lately been brought from Clarendon, Ontario, where it is said to form a bed of fifteen inches in thickness, in a fine grained mica-slate. The mineral is sub-conchoidal in fracture, earthy, bluish-black in color, dull, but assuming the lustre of graphite under the burnisher. It loses by ignition only 0.4 of volatile matter ; by a prolonged calcination in the open air, however, the graphite is burned away, leaving 66.16 per cent of brownish-yellow residue, which yields to acids a little lime, magnesia and oxyd of iron, and then consists chiefly of a silicate in large part aluminous. This anhydrous argillaceous rock thus contains very nearly one-third its weight of amorphous or uncrystalline graphite.

Crystalline graphite is one of the most frequent minerals of the Laurentian veins, in which it occurs under a variety of aspects, sometimes as large plates, or hexagonal tables, disseminated in coarse-grained calcite, vitreous quartz, orthoclase or pyroxene, in

scales between the laminæ of mica crystals, or else forming solid masses in the vein. These masses, when pure, are generally made of broad and thick laminæ, the edges of which, in some cases at least, are at right angles to the sides of the vein. In some cases a large vein will carry two or more bands or layers of pure or nearly pure graphite, separated from each other and from the wall-rock by feldspar, pyroxene or quartz. Occasionally the graphite found in these veins is finely granular, or like that from Warrensburgh, New York, breaks easily into rectangular masses, which exhibit on certain of the fractured surfaces a peculiar finely waved aspect, due to a structure which may be described as consisting of layers of a millimeter or less in thickness, tolerably regular, and made up of minute and narrow lamellæ, arranged at right angles to the layers, and presenting a fibrous or columnar aspect when broken across. When the fracture is with the layers, and thus exposes only the ends of the lamellæ, a granular surface is presented. Fractures at right angles with the layers show an undulating surface, recalling that of certain waved maple woods, and due to the fact that the fibres of the successive layers are not quite parallel with each other. This Laurentian graphite, according to Prof. C. F. Chandler's analysis, consists of carbon, 64.06; carbonate of lime, 32.90; the remaining three per cent being chiefly silica and oxyd of iron. The carbonate of lime is invisibly diffused through the mass, which effervesces freely with acids. It is not in any way connected with the peculiar waved structure, since the graphite from the famous mine of Marinski, in the Government of Irkutsk in Siberia, which presents a structure precisely similar, contains no carbonate of lime, and only small quantities of earthy impurities, amounting, according to Dumas, to 3.7 per cent of the purest specimens.

The Laurentian graphites, then, besides their visibly present foreign minerals, may contain finely disseminated impurities, which detract from their economical value, and can only be detected by analysis.

A Laurentian graphite from Patterson, New Jersey, crystallized in broad lamellæ, gave to Prof. Chandler, 21.0 per cent of pyrites, finely disseminated between the laminæ. This graphite, which by exposure becomes covered with an efflorescence of sulphate of iron, gave also portions of silica, alumina and lime, apparently derived from some mineral like scapolite, disseminated through

the mass, and also enclosed small but distinct brown prisms of apatite.

On the other hand, a graphite from the third lot of the second range of Grenville, Quebec, closely resembling the last in appearance, was found to be of great purity. By long continued ignition it burned away, leaving only 1.27 per cent of foreign matter, which consisted of small, colorless, brilliant grains, apparently of quartz or feldspar, with a minute quantity of fawn-colored flocculi.

Portions of the specimens of graphite sent from Canada to the Exhibition at London in 1862, were furnished to Mr. Regnault, the eminent French chemist and physicist, who has since made use of them in an investigation on the specific heat of this form of carbon. Incidental to this inquiry, they were submitted to a careful analysis by Mr. Cloez; after being calcined to expel any traces of moisture, they were burned in a current of dry oxygen and showed the fact, already suspected by Regnault, that a portion of hydrogen enters into their composition, and is only separated by prolonged ignition in a current of dry chlorine, which at the same time separates the earthy impurities, in the form of chlorids, and leaves the graphite an almost chemically pure carbon. The analysis of a specimen, probably from the same locality with that which gave me 1.27 per cent of ash, gave to Cloez, carbon, 98.56; hydrogen, 1.34; ash, 0.20 = 100.10. Two other specimens of Canadian graphite gave him, respectively, 12.60 and 23.40 per cent of argillaceous ash (*Ann. de Chim. et de Phys.* [4], vii, 450).

The lamellar graphite above noticed, like that of most of the similar graphites known in Grenville and the adjacent region, occurs in veins traversing the crystalline limestones, which are themselves more or less impregnated with graphite. In other cases, however, the wall-rock is gneiss, as in Ticonderoga, New York, where, in addition to the graphite veins, interstratified layers highly charged with lamellar crystalline graphite are extensively mined in the Laurentian gneiss. A small vein, also in gneiss, occurs near Mud Lake, in Loughborough, Ontario. The graphite of the Laurentian veins is similar in its characters to the crystalline graphites of Ceylon, the mineralogical resemblances of whose rocks to the Laurentian series we have already pointed out. These graphites are distinguished by their highly crystalline texture, their metallic gray streak and lustre, and their comparative freedom from ordinary earthy impurities, although, as we have seen, they may include admixtures of carbonate of lime and sulphuret of iron.

There is, however, another class of graphites belonging to the stratification, and evidently of sedimentary origin, containing a large admixture of earthy materials, such as sand and clay. These graphites are generally amorphous, or but imperfectly crystalline, and ordinarily give a much darker streak than the purer varieties. To this second class belongs the earthy graphite from Clarendon, Ontario, already described, and that of many other localities, where the mineral has been formed by the alteration of more or less carbonaceous layers in schistose rocks. The impure plumbaginous schists from the Quebec group of the Eastern Townships of the province of Quebec; the beds of graphite in the micaceous schists of eastern Massachusetts, at Sturbridge, Worcester and elsewhere, which are now recognized to be altered beds of coal; those of the French Alps, which are associated with fossil plants, and those of Passau, in Bavaria, where the mineral is disseminated in gneiss of Laurentian age, are also examples of this second class of graphites. To these we may add the graphite of Borrowdale, in Cumberland, which is found in lenticular masses in altered slates, and the beds of graphite in mica-slate, in New Hampshire, which in some cases passes into a plumbaginous mica-slate, holding garnets. In describing the latter deposits, Dr. Jackson has observed that in the town of Goshen the beds of graphite are intersected with cross veins, which are filled with pure foliated graphite.

These graphites of the second class are distinguished not only by the large proportion of silicious and argillaceous matters with which they are mingled, but also by the very general absence of crystalline texture. This is so evident a characteristic, that Sir Benjamin Brodie, in his recent researches on the chemical relations of graphite, distinguishes two varieties—the amorphous, including that from Borrowdale and from Passau, and the lamellar or crystalline, represented by the graphite associated with quartz from Ceylon, and that from Ticonderoga, New York (*Philos. Transactions* 1859, page 249), the latter of which belongs to Laurentian veins. The graphites from New Brunswick and from Greenland, according to him, approach to anthracite in character, and probably, like that of Massachusetts, pass into this variety of mineral carbon (*Lyell. Geol. Journal*, I, 199.—*Hitchcock's Geol. Mass.*, page 127). Between the amorphous graphite of Brodie, represented by that of Borrowdale and Passau, and the lamellar variety from Ceylon and from the Laurentian veins of North America, may be placed the interstratified graphites of New Hampshire and

of Sturbridge, Massachusetts, which are more or less crystalline in texture. It will probably be found that the highly crystalline lamellar graphite belongs, in all cases, to true veins, where a slow process of deposit has allowed it to assume that mode of aggregation and that purity which characterize other minerals thus deposited.

The presence of graphite in veins under such conditions and associations as have already been described, implies its separation from solution at an elevated temperature, and in this connection the curious researches of Brodie, above referred to, have shown that this form of carbon is possessed of singular chemical properties and affinities, which, when farther studied, may serve to explain its solution and crystallization. Meanwhile, the observations of Pauli have established that when hydrate of soda, mixed with cyanid of sodium, is heated with nitrate of soda to incipient redness, the carbon of the cyanid separates from the liquid mass in the form of graphite. Pauli moreover suggests that native graphite may have been separated from certain carbon compounds by a process analogous to this (*Philos. Mag.*, [4], xxi, 541). The direct transformation into graphite of carbonaceous matter cannot, however, be doubted by geologists, and such a hypothesis is therefore untenable for the stratified graphites. This reaction described by Pauli is nevertheless instructive, as showing that graphite may be separated from solutions at a temperature not higher than that at which, according to Sorby, the minerals which accompany it in the Laurentian veins have crystallized, although we cannot, in the formation of these veins, suppose the intervention of these same chemical reagents as in the experiment of Pauli.

Graphite may undoubtedly be formed at much higher temperatures. Its occurrence in cast-iron is well known; and Brodie, who obtained, by dissolving a graphitic iron in acid, four per cent of lamellar graphite, found it to be identical in physical characters with that met with in nature. Jacquelin also, by the decomposition of sulphuret of carbon in contact with metallic copper, at 800° Centigrade, obtained, together with sulphuret of copper, amorphous graphite. Starting from this experiment, Jacquelin suggests that native graphite may have originated from the distillation into the fissures of rocks of volatile hydro-carbons, which have there, by a decomposition similar to that which takes place in contact with the walls of coal-gas retorts, given rise to a deposit

of carbon that has assumed the form of graphite (*Cosmos*, June 23, 1864). This hypothesis, evidently inadmissible for the graphite found as a disseminated mineral in stratified rocks, is not less so for that found in veins, where its associates are minerals whose presence is incompatible with the high temperature supposed. Graphite, when ignited with carbonate of lime, gives rise to carbonic oxyd, and under similar conditions reduces iron from its oxyd to the metallic state. It even decomposes the vapor of water at a red heat. We are hence led to regard the graphite of bedded rocks as having been formed by the alteration of coal and similar carbonaceous matters at a temperature below redness, while its subsequent translation into the veins, and its deposition in a crystalline form, together with various other minerals, as it occurs in the Laurentian veins, have been effected under conditions which, although imperfectly understood, probably included aqueous solution, and a temperature not far below a red heat.

[ANTHRACITE.—Under this name, for want of a better term, may be described the black carbonaceous matter which has already been noticed as associated with native gold, bitter-spar and a reddish ochre, derived from the decomposition of the latter, at the Richardson mine in Madoc, Ontario. The anthracite seems like the similar material associated with quartz crystals in Herkimer county, New York, to have been deposited contemporaneously with the quartz and bitter-spar, in some cases lining the walls of the vein, and in others appearing in masses an inch or more in diameter in the middle of the veinstone. It is jet black in color, with a conchoidal fracture and a somewhat resinous lustre, and is soft and easily crushed between the fingers.

When exposed to heat in a tube it give out some water, but no bituminous matter; in the open air at a red heat, it takes fire and burns readily without flame, leaving a somewhat abundant ash, whitish and sometimes reddish, consisting of carbonate of lime with some silicious and ferruginous matter, including a quantity of gold. This metal is visible in the form of grains and scales in the recent fractures of the black substance, which, although coal-like in its aspect, resembles more the carbonaceous matter which has been described in the *Geology of Canada* as filling veins or fissures in the rocks of the Quebec group, and is doubtless derived from the transformation of bitumen. This substance, as I have shewn, is in some cases so far altered by oxydation as to have a

composition like that of anthracite, and is then scarcely distinguishable from the Madoc mineral.

The gold, as already stated, occurs both in fine scales, disseminated through the black anthracitic matter, and in large crystalline grains and plates, imbedded in the bitter-spar, sometimes associated with quartz, black hornblende and iron pyrites. From this it would appear that the introduction of the gold was not only contemporaneous with the deposition of the bitter-spar, but continued after the introduction of bitumen.

Carbonaceous matters not unfrequently occur in mineral veins in other regions, and are met with in several localities in the Laurentian rocks of Scandinavia, where, according to Daubrée, in the silver mine of Kongsberg, a matter allied to anthracite and similar to that of Madoc, occurs in mammillary masses imbedded in the calc-spar of the veinstone, and sometimes penetrated by native silver (*Ann. des Mines* [4], iv, p. 260). In other veins in that region the presence of bitumen is indicated, and in the beds of magnetic iron ore, found in gneiss at Dannemora, small masses of a matter closely resembling bituminous coal in composition, and penetrated by quartz veins, occur in the midst of the ore. See in this connection Igelstrom's recent observations on the bituminous gneiss of Wermland, in Sweden (*Amer. Jour. Science*, [2], xlv, 38). According to Daubrée, both graphite and anthracite, where they occur in the ancient rocks of Scandinavia, are accompanied by bitumen. No such associations have hitherto been observed with the graphite of our Laurentian series.

The above details are chiefly taken from the *Report on the Gold of the County of Hastings*, already cited.]

P. S.—More recent researches by the Geological Survey of Canada, have shown that the rocks of Hastings county, Ontario, noticed on page 48, rest unconformably upon the Laurentian, and belong to one and possibly two distinct systems. The upper and larger portion consists in great part of mica-schists and micaceous limestones, while at the base are great masses of dioritic and hornblendic schists with iron ore, possibly of Huronian age. To the basal portion of this upper series belong the steatite, page 79; as also the gold, page 66; the bismuth ores of page 91, and the anthracite of page 97. The upper works of Hastings are noticed by me in the *American Journal of Science*, for July, 1870, page 85.

T. S. H.



(F.)  
NOTES AND OBSERVATIONS ON THE COHOES  
MASTODON.

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BY JAMES HALL, LL. D.

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In the month of September, 1866, the workmen engaged in excavations for the foundation of a new mill to be erected by the "Harmony Mills Company of Cohoes, N. Y.," discovered the lower jaw of a Mastodon with a single foot bone, resting upon a projection of rock between two depressions or concave walls of small pot-holes, in the margin of what afterwards proved to be a larger pot-hole.\*

The position of the lower jaw thus found, was not far from the water level as represented in the illustration (Plate V), and a little outside the line of the foundation of the mill. At this time the excavation had been carried on to the depth of about twenty-five feet from the original surface. This surface on one side was of clay and earth, which had formerly been filled in to cover a large swampy depression originally existing over a considerable area. On the side farthest from the river or to the westward, the excavation had been made by blasting the slates of the Hudson river group, as shown in the illustration. After the removal of the artificially deposited clay, the workmen came to the original swamp, the approximate limits of which, as formerly existing, are represented on the diagram, Plate IV.

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\* These depressions, lying more than one hundred feet above the river level opposite that point, were filled with water oozing through the slate from the canal and raceways above. Although presenting at this time only the appearance of concave areas or niches in the upper part of the main cavity (as shown in plate V), it was evident that they had originally been independent pot-holes, which from continued wearing had broken through their walls at two points, thus communicating with the larger and deeper one, and by degrees becoming portions of it. The gravel and pebbles found in the concavity of each, bore attestation to their origin.

Several thousands of loads of muck or peaty soil with trunks and branches of decayed trees had been removed, previous to coming to the level where the jaw was found. At that time the limits of the pot-hole were pretty well defined, the walls on the western and northwestern sides being much higher than those on the eastern and southern sides. This pot-hole, represented in Plate V, communicated by a narrow opening with another nearly as large on the north side, as shown in the diagram; the conditions of the two being quite similar. At this level the pot-hole presented an oval form with the longest diameter from east to west; the more easterly portion from I to H was found to be shallow, and the deeper part was nearly circular or broadly oval, with a mass of rock remaining like an island in the center. At the level recorded on the diagram, the entire pot-hole was filled with peaty soil, branches and trunks of trees of several species, pine and hemlock cones, and other material in a condition similar to the usual deposit in the bottom of swamps and bogs. Among these fragments of wood were many which had been gnawed by beavers,\* the marks of teeth remaining distinctly visible on the soft and water soaked material. These had probably been floated into this place during freshets or high water of the river at a period long anterior to our knowledge of the country.

Although our principal interest is with the pot-hole No 1, it will be interesting to notice that it is connected with another similar cavity of irregular form on the northwest marked No. 2. (See explanation of diagram.)

The discovery of a jaw with a single bone in such a position, naturally led to the inference that the other parts of the skeleton would be found at the bottom of the pot-hole, could it ever be reached, and the progress of the excavation was watched with great interest. After considerable delay,† the excavation was resumed and the peaty earth and fragments of trees removed from the eastern and central part of the pot-hole, which latter proved to be the deepest portion. In the bottom of this cavity lying upon a bed of clay, broken slate, gravel and water worn pebbles,

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\* This fact was first noticed by Dr. Woolworth, and it is probable that much similar gnawed wood had been removed during the excavation, before our examination.

† Finding the difficulty of reaching the rock for foundations of the walls, an arch was thrown across from A to B, a second from B to C, and a third from C to D, and it was only in the progress of excavating for the line of pillars as shown in the diagram, that the bottom of the pot-hole was reached.

and covered with river ooze and vegetable soil, lay the principal parts of the Mastodon skeleton. The first parts uncovered were the bones of the hind legs with a portion of the pelvis. The head with tusks unbroken and undisturbed was directed to the eastward, and was partially inclined against the sloping wall; the vertebræ with exceptions, the ribs in part, one fore limb and scapula followed, the posterior parts lying more to the westward or southwestward, but all in juxtaposition. The absence of the lower jaw and some of the larger limb bones was obvious, and but for these we might have supposed that the entire skeleton had been drifted into this pot-hole, and covered with river ooze and peaty soil. The point at which the principal bones were found, is indicated by the letter *b*, and horizontal lines on the diagram. On further examination, other bones were discovered at the points marked *c*, *d*, *e*, thirty or forty feet distant from *b*, and at a somewhat lower level than the main part of the skeleton, but still above the gravel. Expecting to find some at least, of the remaining bones, efforts were made to remove all the peaty earth and loose materials, but this was never fully accomplished. Later discoveries, however, induced a doubt whether the remaining bones might not have been scattered in other directions. After clearing a considerable space in the bottom of the pot-hole, the gravel was penetrated by a sharp steel rod to a depth of ten feet without striking the rock. We have, therefore, no means of knowing the entire depth of the pot-hole, though explored at least sixty feet from the original surface without reaching rock.

At a later date, sometime in February, 1867, during excavations upon another part of the ground outside of the mill, a small pot-hole was opened in which were found bones of the right fore leg and foot. This point, marked *f* in pot-hole No. 3, is more than sixty feet to the southwest of the place where the principal bones of the skeleton were found, and at least twenty feet higher.

That these were all parts of the same skeleton, we have every evidence which the circumstance of dismemberment would allow. The jaw evidently belongs to the skeleton, both from the articulating surfaces, and from some peculiar features which will be noticed elsewhere. The bones of the fore leg and foot were of corresponding size, and in a similar condition as regarded the

epiphysis and other characteristics. Moreover, there was no duplicate of any bone found, and many important ones still remain undiscovered. The facts all prove that a single skeleton of Mastodon was dismembered, and while a large portion of the bones remained in juxtaposition, others were widely scattered, and some of them perhaps were carried beyond the area examined.

From these facts, it was natural to infer that a Mastodon had floated down the ancient Mohawk, when its level was more than a hundred feet above the present bed below the falls; and that lodging upon the rocks, it had gradually become dismembered, and its parts transported to different points and deposited in the depressions adjacent. But to sustain this view it was necessary for the body of the Mastodon to have lodged upon the rock at, or about, the close of the period when the tumultuous waters had ceased to wear the pot-holes, and before the deposit of any of the finer materials, such as river ooze and peaty matter had accumulated, for the bones were lying directly upon the clay and broken slate, and above the water-worn pebbles.

When, however, we began to look at the manner of dismemberment and distribution of the parts, new difficulties arose. While the skull with the cervical vertebræ, from the second to the seventh inclusive, were essentially in their natural relations, the atlas was missing, and not found at all. The lateral processes of the second and third, and the spines of the fifth and sixth vertebræ were broken off. Of the dorsal vertebræ, the first four, the eighth, twelfth, and the last five remained, while the other nine were absent. Similar conditions existed in respect to other bones. In the right foreleg, the head of the humerus alone remained in that connection, while the radius and ulna, and some foot bones had been removed to the distance of more than sixty feet to the southwest (at *f*), and at a level twenty feet above the principal parts of the skeleton. It is scarcely possible to account for the distribution of parts in this manner, if due to the action of water alone, and for their separation if resulting from the decomposition of their connecting ligaments. The removal of the atlas, while the adjacent parts preserved their relations, presents, as I conceive, an insurmountable difficulty to the theory that the body was macerated in water and its parts distributed as decay and decomposition of the muscular integuments supervened.

In the discussion of the question regarding the mode of distri-

bution of parts, Hon. A. S. Johnson first suggested that the skeleton must have been imbedded in ice, and that during the thawing of the mass the bones had become separated and dispersed as they were found. The pot-holes were supposed to lie in the bed of a former river channel, at a time when the waters flowed at a much higher level than at present; this view was the only one entertained at that time, and our investigations were directed to the discovery of evidence in support of this hypothesis.

An examination of the present river channel for some distance above the falls and of the gravel accumulation in what we inferred to have been the former valley of the river, gave no satisfactory solution of the difficulty. To produce pot-holes of the depth and magnitude of those examined at Harmony Mills, would have required not only a large body of water, but a considerable fall in the stream. A survey of the valley above, furnished no evidence that at any time subsequent to the drift period had there been a barrier or elevation to give a descent to the water sufficient to produce such a result as described. We were, in fact, able to trace similar pot-holes to the west and northwest, directly beneath the drift gravel of the old valley, thus connecting their occurrence with a condition of things no longer existing.

In the following spring and summer, a careful survey of the Cohoes falls and the surrounding country was made, mainly with a view of determining the relations of the pot-holes in which the Mastodon remains were found, to those of the River bed and adjacent valley. From this survey it was clearly ascertained that the large and deep pot-holes were entirely outside of the present river channel; that all the pot-holes existing within limits overflowed by the present Mohawk river in any of its stages, are shallow basins, the larger part of them having a diameter at the top equaling or greater than the depth. The form or contour of these latter, was such that they were readily distinguished from those on the banks of the river at a higher level. We therefore began to distinguish the pot-holes as *ancient* and *modern*, and with a few exceptions about the falls—apparently the bottom of ancient pot-holes not yet quite worn out—all those of the river bed seem to be of modern origin.

It was found, moreover, that the ancient pot-holes did not follow the line of the present river valley. An examination upon the north side of the river detected numerous small, somewhat circu-

lar swampy depressions, while the shale rock underlaid the general surface, often appearing above it, and for long distances only covered with a shallow deposit of soil. These depressions were sounded with steel rods and found to be filled with peaty matter, having all the characteristics of the large pot-holes on the south side of the stream. In comparing the observations made upon the two sides of the river, it was found, so far as our observations extended, that the ancient pot-holes are distributed in a general north and south direction. It is true that others were observed on both sides of those shown upon the map, and some of them farther to the south, but in their general direction they cross the valley instead of being parallel with it. From the careful examinations made in the broad river-bed above the falls, during the low water of summer, it is not possible that any of the large and deep pot-holes could have escaped our notice had they existed.

We have, therefore, by these observations determined that the water of the present river, neither above, below, or at the falls, produces pot-holes of the character of those in which the Mastodon bones were found. We find that the pot-holes termed ancient do not follow the present river course, and we infer that they have had a different origin, since the present river produces nothing of similar character.

In the bottom of all these ancient pot-holes, there is a considerable space occupied by gravel and pebbles, which are chiefly or almost wholly of hard quartzite, a partially metamorphic condition of the Potsdam sandstone. Had these pot-holes been made by an ancient river flowing in the old Mohawk valley, we should expect to find the pebbles occupying them to be of rocks brought down by the river from the west. Looking along the line of the present valley westward, we find no rock in place that would have produced such pebbles, though similar pebbles occur abundantly among the gravel in the lower part of the Mohawk valley. Turning to the northward we find large exposures of the sandstone or quartzite, from which these pebbles might have been derived, had there been the means of transporting them.

The breaking down of these rocks and the transport of fragments is usually attributed to the action of ice, and the rounding of these into pebbles is due to the subsequent action

of water. The agency which transported the quartz pebbles of the Mohawk valley, was doubtless the same as that which transported those found in the pot-holes at Cohoes, and their smooth rounded condition is due to the action of water, which moving them violently about in those places, not only produced the exceeding smoothness of these pebbles, but at the same time caused the depressions in the rocky surface, which were finally worn into the deep pot-holes which we now find.

It is not difficult to understand how fragments of rock and pebbles may be transported by ice as they become imbedded in the moving glacier, but the manner in which these fragments, while under glacial influence, have aided in the formation of the pot-holes, is not so evident, and for the explanation, we must have recourse to some peculiar phases of glacial action.

In a discussion of this question before the National Academy of Science at Hartford, in August, 1867, Prof. Agassiz stated in regard to pot-holes of this character, that they are never formed by fluvial action; that no river, however large, flowing over the rocky surface could produce them, but that they are the result of glaciers, or rather caused by water from the surface of a glacier falling into crevasses and forming cascades, often a thousand feet in height. These cascades falling upon the rock of the bottom, aided by fragments of stone which are likewise carried into the crevasses, or moved along the base of the glacier, produce depressions which are worn into deep holes (similar to those described), which he had himself examined by being let down to the bottom of the crevasses in some of the glaciers of Switzerland. This evidence, therefore, ought to be conclusive as to the manner in which similar pot-holes are produced beneath existing glaciers.\* We are at least driven to some other explanation of the production of these ancient pot-holes than attributing them to fluvial action, for neither along the Mohawk or any river, nor about the rapids or falls of existing streams do we find any similar ones, though in

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\* Since it would require a long period of time for the falling water to produce these cavities or pot-holes, it is not easy to conceive how, with the constantly advancing motion of the glacier, these cascades, falling through the crevasses, could have remained long enough in one position to have produced such a result. The explanation given by Prof. Agassiz, is that the crevasses are produced by the physical features of the underlying surface, and that although the mass of the glacier moves forward the crevasse is maintained at or near the same place for a long time.

certain favorable situations there are meagre representations of them having a depth rarely of twenty feet.\*

Admitting the view of the subject as presented above, it would appear that, during the glacial period, the surface water falling through the crevasses in the vast accumulation of ice, eroded these deep cavities in the rock beneath. As a matter of course, the fragments of rock falling in the crevasses, or those accumulated beneath the glacier, would aid in the process of wearing and thus become smooth and polished pebbles. At the close of the glacial period or at any time during its continuance, the thawing of the ice would release any objects frozen into the mass, and these would be dropped upon the surface or promiscuously distributed. If, by some means, the body of a Mastodon had become imbedded in the accumulating glacier—the expansion and contraction of the ice, the cracking and filling of these cracks with water and its subsequent freezing—these combined agencies might dismember the bones in the remarkable manner before indicated, causing a separation of attached or adjacent portions in a way that no other means could accomplish. Thus, while the bones constituting the greater part of the skeleton remained in close proximity, and were deposited in the deep pot-hole as found, other portions which had been abruptly separated by the expansion due to freezing and thawing, were deposited in other places more or less distant. We have in fact an exhibition of what we may suppose would take place were the carcase of an animal to be frozen into the solid ice, and remain year after year subject to the varying conditions which produce cracks and crevasses, the filling of these with water and again freezing, the whole mass undergoing at the same time a slow movement in one direction, until finally the ice is thawed, either by its extension southward or by the termination of pre-existing conditions, and the dismembered portions of the skeleton fall to the bottom of the water thus produced.

This argument, if accepted in its general conclusions, would place the period of the Mastodon existence before the glacial epoch; and the facts would indicate its extermination by the advent of the glacial phenomena over those parts of the country where glaciers existed.

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\* In examples of this kind, it is not always possible to decide, whether the pot-hole may not be due to some action anterior to the existing stream.



I am aware that the condition in which these remains have usually been found, has induced the belief that they have lived during the present epoch, or since the surface of the country assumed its present conditions. The usual explanation of the cause of extinction is not very satisfactory; the skeletons and parts of skeletons found in the bottom of peat bogs or mosses are supposed to have come there from the animal having voluntarily walked into the swamp, and becoming mired, has thus died and subsequently been covered by mud and peaty accumulations.

This argument of itself without any opposing facts, is far from satisfactory, and it seems to me very unnatural that any animal, except in extremely rare instances, would thus voluntarily approach and enter upon such fatal ground. There are many very obvious objections to such a conclusion. It often happens that the margins of these swamps as now existing, are more dangerous than the centers, and would never admit so heavy an animal to pass beyond their limits. Again, so far as the food supposed to have been eaten by these animals is concerned, it is quite as abundant on the margins as in the middle of the swamps, and from the known conditions it is more than doubtful if any vegetation flourished in the center of the bogs, at least, at the time when they are supposed to have been invaded by the Mastodons.

In fact, the peaty matter forming the morass in which these animals are supposed to have become mired, has been accumulated subsequent to the deposition of the Mastodon remains which lie beneath it. Then, we often find in these places a single skull, one or two dismembered bones, a tooth or two, or a tusk, without evidence of other parts. Had the animal voluntarily walked into these places and died there, we should have had some other evidence than these fragmentary parts of the skeleton.

I have examined a small swampy depression in which two teeth of a Mastodon were found, and which was not sufficiently broad or deep to have buried an entire animal of Mastodon dimensions; and had the entire body by any chance been brought there, it is not probable that there would have been only the two teeth remaining. In another place I have seen a single tusk exhumed from a fresh-water shell-marl deposit, beneath a peaty accumulation, without other indications of the skeleton, and certainly the teeth are as likely to be preserved as the tusk. It is not uncommon to find one tooth or more in situations where no

other parts of the skeleton are found. In some instances, the occurrence of a tooth in a gravel bed has been attributed to its transportation by some river current from a swamp or alluvial deposit. While a few bones, the teeth, or parts of tusks are of frequent occurrence, the entire skeleton is very rare. At the Big Bone Lick, in Kentucky, numerous teeth, tusks and bones have been found, but nothing so far as I know approaching an entire skeleton. It is doubtless quite true, however, that any skeletons of these animals, left upon the surface or imbedded in the loose soil or gravel, would in time disappear leaving only the more indestructible portions such as the teeth.

I do not believe that any of the Mastodon remains which we find, are of animals that wandered into swamps or sought their food in such localities, and thus became mired. On the contrary, it appears to me more natural and more in accordance with the conditions in which they are found, to suppose that they were deposited in a pool or pond of water, which, during subsequent time has been invaded by the gradually encroaching vegetation, and the accumulation of the peaty deposit has in this manner filled the area previously occupied by water, and thus covered the Mastodon remains. These swampy depressions are often partially or almost entirely surrounded by gravel hills or ridges; and it seems a natural solution of the question to suppose that these hills are the remains of the moraines from the glacier, more or less modified by the action of water, and that the Mastodon remains have dropped from the melting ice, which left the pool or pond where the vegetable deposit has subsequently accumulated.\*

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\* In reference to the skeleton of the Mastodon found near Newburgh (the Warren Mastodon), Dr. Charles A. Lee writes me as follows: "As I visited the spot soon after the skeleton was discovered, and examined everything connected with the locality, I can confidently assert that the skeleton was *not* found in a stratum of shell-marl below the peat or muck, *but was wholly immersed in the muck or peat*, with a thin layer of marl over it, produced from small fresh water shells, such as we very often find in our swamps and peat-beds."

The order of succession of the materials in these bogs or swamps is usually as follows:

1. Muck, peaty soil or peat; often with trunks and branches of trees.
2. "Shell-marl" made up of the exuvia of fresh-water shells, the precipitation of calcareous matter brought in by the percolation of water through the adjacent gravel, and all intermingled with a fine clay. (This shell-marl is not always present.)
3. Clay, very fine and impalpable above and becoming coarser below.
4. Sand or gravel, or both together.

Now, the Newburgh or Warren Mastodon skeleton being covered with a thin stratum of shell-marl, precludes the theory that the animal had walked into this bog. The deposition of the shell-marl was essentially completed in the pond or lake before the vegetation had invaded that part of its area.

I had arrived at this conclusion without further evidence than that presented above, when speaking of the subject to Prof. Leidy, he informed me that there were in the collection of the Philadelphia Academy of Natural Sciences, a tusk and tooth of Mastodon, which had been curiously worn by some agency, which might have been glacial action, the explanation of which had not before occurred to him. I subsequently examined these specimens which were obtained from the Big Bone Lick in Kentucky, and found the tooth worn from one side nearly half-way through in a manner which indicated glacial action, as evidently as do those fragments of rock which have been imbedded in ice, and worn down by the movement of the glacier over a hard surface below. The tusk, which is about two feet long, exhibits a similar condition, but is worn for its entire length upon both sides, and presents a very curious and interesting appearance.

More recently, Prof. Cook has shown me a fragment of the distal extremity of a tusk, in the collection of Rutger's college, which is worn down and polished on one side, still preserving the glacial striæ. This specimen is likewise from the Big Bone Lick in Kentucky.

We have in these specimens what I conceive to be most unequivocal evidence of glacial action, or an effect such as is usually attributed to that action, upon a tooth and tusks of Mastodon ; and these facts alone should be conclusive regarding the existence of the Mastodon preceding the glacial epoch.

With our present knowledge, it would appear that this accumulation of bones, teeth, and tusks of Mastodon, in Kentucky, may have been caused by the melting of a glacier in which they had become imbedded, and being gradually pushed forward to its southern limit, had been deposited in this place. There are other similar localities of less importance and extent, where Mastodon remains have been obtained in considerable numbers, and it is not improbable that a critical examination of all known collections may furnish some further evidence of conditions similar to those indicated by the specimens in the Museums of the Philadelphia Academy of Sciences and of Rutger's College.

However heterodox these views may appear, as opposed to the generally received opinions of the age and relations of the Mastodon, I feel quite sure that some other hypothesis than the one usually entertained must be adopted in order to arrive at a satis-

factory explanation of the mode and conditions of distribution and inhumation of the Mastodon and Fossil Elephant remains of this country.

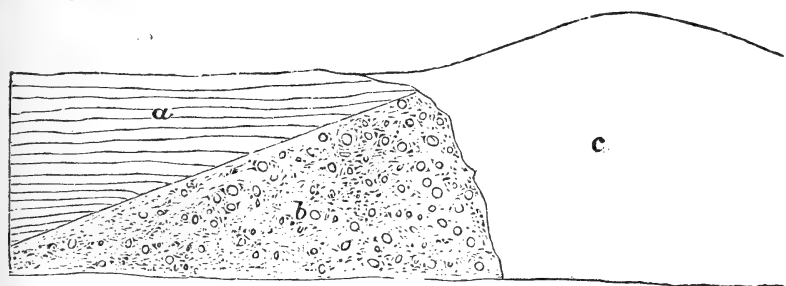
In advocating this opinion regarding the extermination of the Mastodon, I have reference to the remains as they have come under my own observation, and I do not mean to be understood as opposing *in toto*, the views so generally entertained, that the Mastodon has existed during the present epoch ; or, that the opinion held by some of our scientists, that the animal may have existed both before and since the glacial period, is untenable. I refer only to the phenomena usually accompanying these remains, and the conditions attending those which have been exhumed within the State of New York and adjacent parts of New Jersey, and to some extent in other parts of the country. The locality of Big Bone Lick in Kentucky, which has furnished the fragmentary parts of so many skeletons (and some other western localities) I have not visited ; but the evidence already given in relation to the bones from this place, indicates very clearly that they had suffered from glacial action, and the animals were, as we infer, of the glacial period.

Returning to the consideration of the geographical and geological surroundings of the Cohoes Mastodon, we find the following conditions: the Mohawk river having a generally easterly direction, and flowing through a broad alluvial valley except for a short distance at Little Falls, makes a bend to the northward after leaving Schenectady, then gradually curving to the southward for a few miles, its course is more directly to the northeast as far as Crescent, where it turns abruptly to the southeast, uniting with the Hudson River below Waterford, and at a point ten miles above Albany. The Cohoes Falls is on the Mohawk about one mile above its junction with the Hudson River. The relative position of these places and the course of the river is given on the small accompanying map, Plate I.

The area to the southward, as shown upon this map, is covered by drift and estuary deposits in the order of boulder-clay and gravel below, above which is an evenly stratified clay, graduating into a loam, and finally to a fine yellow sand which covers much of the area between Albany and Schenectady along the line of the railroad, except where broken by ravines and small water courses. The general elevation of this plateau is about 200 feet above tide water. Some of the higher hills to the northeast rise to the height of 325 feet. The relations of the clay and gravel are often seen in exca-

vations, and in a few instances, sections are disclosed in the progress of working.

The accompanying section from a point in the north part of Albany, will serve to illustrate the superposition of these beds.



a. Stratified clay.

b. Gravel and sand.

c. Grassy slope over gravel hill.

The gravel is mainly of water-worn materials, though the lower beds do not exhibit the result of the sorting process or the entire smoothing of the pebbles: they are often found resting upon a boulder-clay or a mixture of clay and gravel, the whole covering an extremely uneven surface of slate rock, which has previously been worn into great inequalities as we often see from its exposure along the Hudson and Mohawk rivers, and at a few points near Schenectady and along the Normans Kill. The pot-holes in the slate rock have been formed before the final deposition of this mass of gravel, which is of extremely unequal thickness, in some places acquiring a depth of two hundred feet or more, and again thinning down so as almost to disappear. Wherever lines of bedding can be discovered, the strata show evidence of the influence of violent currents in the discordant stratification, the partial wearing away of the finer material, and the substitution of coarser beds, or the deposition of very coarse pebbles above the finer beds of sand. The superimposed beds of clay and loam are the results of a quiet condition of the water, in which the finer sediments were deposited without interruption for a long time, closing with the fine yellow sand of the plains. These clay and superincumbent sand deposits are of essentially uniform character throughout much of the Hudson valley, extending northward to Saratoga, Lake Champlain and the St. Lawrence valleys.

It is through this deposit of estuary clay and sand that the Mohawk makes its way in the neighborhood of Schenectady, and gradually exposes more of the gravel deposits as it approaches the Hudson. Soon after leaving Schenectady, the shales and har-

der beds of argillaceous sandstone are seen near the river bank and forming its bed, but the stream appears to be flowing in an ancient wide depression, having accomplished but a very moderate amount of erosion of the rock in modern times. A section one mile below Crescent (Pl. II), gives the contour of the valley at that point. From there the river channel gradually deepens in the slate till the nearly vertical banks are from twenty to thirty feet above the river level, and even fifty feet at some points, though by no means uniform or presenting the same elevation on the two sides. At the falls, the river makes a sudden descent of seventy feet (Plate II), and pursues its course between the almost vertical walls of slate rock, which rise from eighty to more than one hundred feet above the river bed. The width of this channel just below the falls is about eleven hundred feet, and at a point six hundred feet lower down the stream it is eight hundred feet, presenting a pretty even rock bottom, except along the center where a deep narrow channel has been worn, as shown in the section (Plate II.) In the summer time this rocky bed is dry, all the water being confined to the narrow deep channel, but in times of high water it is covered to the depth of fourteen feet.

At the base of the falls, and for some distance below, the channel is irregularly deepened as shown in the transverse section of the river at that place (Plate II, Fig. 3). The same feature is shown in the longitudinal section (Plate II, Fig. 4). The deepest point, however, is not directly below the falling water in the center of the channel, or at the base of the fall, but at some distance in advance. The deepest points near the fall are upon the west side; and though both here and along the entire width of the stream, there are great irregularities in depth, there are no defined pot-holes. In the deep channel below, there are a few small islands of rock, and some irregular pot-holes along its margin, which for the most part are shallow pools, though some of them have a depth of ten or twelve feet. On the margin of the fall above, there are a few deeper pot-holes, as shown in the longitudinal section of the river-bed; their principal region is an area above the falls, within the limits of the rapid water as it approaches the precipice.

THE MAP OF COHOES FALLS AND VICINITY (Plate III), is a portion reduced in scale from a much larger surveyed map of the river and valley in the vicinity of Cohoes. The width of the river below the falls is indicated by the topographical lines, and the narrow deeper channel is given as surveyed. The upright figures

in this and other parts of the map indicate the depth of soundings in feet, the inclined figures being used to designate a list of pot-holes. By a study of the sections and map a very clear idea of the river bed may be obtained.

Throughout all parts of the river bed and channel, we search in vain for evidences of pot-holes of the character of those described as containing pebbles of quartzite and in which the remains of Mastodon were found. Ascending the banks at any point, however, these ancient pot-holes meet us wherever the gravel or boulder clay has been removed from the surface of the rock. They are of all dimensions from one foot to fifty feet in depth and diameter. Sometimes they are entirely without pebbles, having become filled with clay or peaty earth according to surrounding circumstances, but usually the lower part is occupied by pebbles. In some instances it would appear as if the pot-hole was mainly due to a large boulder having dropped upon the surface of the rock, and the water wearing around it had caused the first depression in the surface, and this was increased by the lodgement of smaller pieces, which being set in motion by the water, produced the wearing to the depths we find them.

Upon the ground covered by the diagram of pot-holes (Plate IV) in the vicinity of Harmony Mills, these cavities were found in all varieties of form and in all stages of progress. Although twenty-six pot-holes were examined and noted upon this area, it is not probable that one-half were seen, on account of the covering of clay, etc., which prevented an examination over a large part of the ground. The large peaty bog, indicated on the right hand, was penetrated far enough to prove it to be an enormous pot-hole, but its depth was not ascertained. There was likewise a depression in the rock from the large pot-hole No. 1, leading towards this bog, but no outlet from the latter could be traced. Similar pot-holes were traced along the bank further to the southward, and others have since been discovered at a greater distance in the same direction.

Although it may be said that there are general characteristics by which these pot-holes can be distinguished from those of modern origin, like those of the present river bed, they were nevertheless of very various forms, sometimes wide at the top and in other cases quite narrow, and enlarging downwards. A section of one of these, more extreme than the others, is given on the diagram. The smaller ones were simple and entire on their margins; those of larger

size were irregular, as if several smaller ones had been broken through, and the whole combined in one as shown in the sketch Plate V.

### THE SKELETON.

All the parts of the skeleton found at the different points designated, were presented to the State Cabinet of Natural History by Alfred Wild, Esq., President of the Harmony Mills Company, and have been mounted in the position represented in the figure, Plate VI. The missing bones were modeled from opposite corresponding parts or from adjacent ones, and afterwards cast in plaster of Paris. In some instances recourse was had to the Warren Mastodon skeleton, of which careful examinations and comparisons were made. The work of modeling the parts, and superintending the work of mounting was performed by Mr. G. K. Gilbert of Rochester, assisted by E. E. Howell and J. W. Hall.\*

The lower jaw of the animal which was the first part obtained, presented some remarkable peculiarities. The left ramus was entire carrying the fifth and sixth molars. The right ramus was obviously smaller, the condyle had been eroded or dissolved in great part, and the surface roughened; it carried but a single tooth, which was evidently the fourth or fifth molar, and this was thrown forward giving an inclination to the upper surface of about thirty degrees—a condition apparently due to the want of support which would have been afforded by the last or sixth molar had that tooth been developed. On the outer face of the right ramus, beneath the coronoid process, there is a perforation in the bone of one-tenth of an inch in diameter and which can be penetrated to the depth of two inches. The portion of bone surrounding this opening is corrugated as if ossified from several centers or nuclei, the laminae presenting an irregular concentric arrangement. From the position and appearance of this opening it is quite natural to infer that there had been an abscess in that jaw, or disease and decomposition of the undeveloped sixth molar.†

The skull had participated in these derangements and was larger on the left side and somewhat distorted. When viewed

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\* The work of the survey of the river bed and adjacent country was also in charge of Mr. Gilbert. The survey and measurement of pot-holes in the neighborhood of and beneath the mill, and the diagram of the same published, were made by Mr. R. P. Whitfield.

† A section of the jaw has since been made and this portion removed, proving the correctness of the inference regarding its former condition, but the cavity remaining was of smaller dimensions than anticipated.



from above, it shows a flexure of the median line with the convexity to the left. The upper molars on the right side were more exsert than those on the left, a condition probably due to the want of antagonism below. The head in all its parts, as well as some portions of the skeleton, participated in this want of symmetry, consequent apparently upon this condition of the jaw.

**PARTS PRESERVED AND PARTS LOST.**—The following enumeration of the preserved and missing parts of the skeleton, together with their measurements and comparisons, have been prepared by Mr. G. K. Gilbert.

*Head.*—Preserved: skull and jaw nearly entire. Lost: portion of left tusk; 6th left upper molar\*; both styloid processes; right condyloid process of jaw.

*Cervical Vertebrae.*—Preserved: 2d to 7th inclusive. Lost: atlas; right lateral processes of 2d and 3d; spines of 5th and 6th.

*Dorsal Vertebrae.*—Preserved: 1st, 2d, 3d, 4th, 8th, 12th, 16th, 17th, 18th, 19th and 20th. Lost: 5th, 6th, 7th, 9th, 10th, 11th, 13th, 14th and 15th; neural arch of 2d; spines of 18th and 19th; right lateral processes of 19th and 20th.

*Lumbar Vertebrae.*—Preserved: 1st and 3d. Lost: 2d.

*Sacral Vertebrae.*—Preserved: 1st to 5th complete.

*Caudal Vertebrae.*—Preserved: 3d, 4th, 5th and 9th. Lost: 1st, 2d, 6th, 7th, 8th and 10th to last.

*Ribs.*—Preserved: right, 7th to 13th, 19th and 20th; left, 1st, 4th, 5th, 8th, 10th to 14th, 17th and 19th. Lost: right 1st, to 6th, 14th to 18th; left, 2d, 3d, 6th, 7th, 9th, 15th, 16th, 18th and 20th.

*Sternum.*—Preserved: 2d (?) segment. Lost: 1st, 3d to 5th (?)

*Pelvis.*—Preserved: right half, and left epiphysis of ischium and spine of ilium. Lost: left half.

*Right Fore Leg.*—Preserved: radius, ulna, and head of humerus. Lost: scapula and humerus.

*Foot.*—Preserved: scaphoides, lunare, cuneiforme, pisiforme, trapezoides (divided into two bones), unciforme, and of the first phalanx the 2d, 4th and part of the 3d. Lost: trapezium, five metacarpals, 1st and 5th of first phalanx, all of second and third phalanges, and all sesamoid bones.

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\* These parts were exhumed with the head, but were subsequently taken from the place by some person unknown.

*Left Fore Leg.*—Preserved: scapula, humerus, radius and ulna. Lost: lower epiphysis of radius and ulna.

*Foot.*—Preserved: the first phalangeal bone of the third toe—only.

*Right Hind Leg.*—Preserved: femur and patella. Lost: tibia and fibula.

*Foot.*—Preserved: Metatarsals of 2d and 4th toes. Lost: the remaining 33 bones.

*Left Hind Leg.*—Preserved: femur, patella, tibia and fibula entire.

*Foot.*—Preserved: astragalus, os calcis, naviculare and cuboides. Lost: the 3 cuneiformes, 5 metatarsals, 13 phalangeal bones, and 10 sesamoid bones.

*Summary.*—In the first column are the number of bones preserved in part or whole; in the second, of those entirely lost.

The number of sternal segments is unknown, and the same may be said of the caudal vertebræ. The number of ossified sesamoid bones of the feet varies according to the age of the individual.

	Preserved.	Lost.
Head.....	2	2
Cervical Vertebræ.....	6	1
Dorsal Vertebræ.....	11	9
Lumbar and Sacral Vertebræ.....	7	1
Caudal Vertebræ.....	4	22 (?)
Ribs .....	21	19
Sternum .....	1	4 (?)
Fore Legs.....	7	1
Hind Legs and Pelvis .....	7	2
Fore Feet.....	12	64 (?)
Hind Feet.....	6	64 (?)
Total.....	<u>84</u>	<u>189</u>

*Epiphyses.*—A large number—more than half—of the loose epiphyses of recovered bones were lost; but, as these pieces were with two exceptions, quite small, the fact of their loss is rather historical than geological. More remarkable is the preservation of several epiphyses belonging to bones that were not found.

*List of Vacant Epiphysial Surfaces.*—Spines of cervical vertebræ, except 2d; of dorsal, except 3d; of 1st lumbar, and all of sacral. Right lateral processes of all cervical, of the 18th dorsal, and of the 1st and 3d lumbar vertebræ. Left lateral processes of the 2d, 4th and 5th cervical, and of the 18th, 19th and 20th dorsal vertebræ.

Heads of all ribs. Distal ends of left ulna and radius. Proximal end of left fibula.

*List of uncomplemented Epiphyses.*—Those of the proximal end of the right humerus, of the left ischium, of the spine, of the left ilium, and of the neural spine of a dorsal vertebra.

**DISTRIBUTION IN POT-HOLES.**—The bone found with the jaw is a phalangeal one—the only discovered bone of the left fore foot.

The twelve bones (two metatarsals, seven carpals and three anterior phalangeals), found with the right radius and ulna are all of the right foot.

**OTHER SKELETONS.**—The Warren Mastodon Skeleton, to which frequent allusion is made below, was exhumed near Newburgh, in 1845, and now stands in the Warren Museum in Boston. It is nearly complete,\* and forms the subject of a memoir.†

The Baltimore Mastodon was found likewise in Orange county. Its many deficient bones were supplied by wooden models, and the whole exhibited in Peale's Museum, Philadelphia; the dismembered bones now lie in the Warren Museum.

The Cambridge Mastodon, discovered in Warren county, New Jersey, in 1844, is smaller and less complete than the Warren skeleton; it stands in the Anatomical Museum of Harvard University.

Reference is also made to the "Elephant Pizarro," a large adult skeleton standing by the side of the Warren Mastodon, and to the "Albany Elephant," mounted in the museum of the Albany Medical College.

**MEASUREMENTS.**—All the smaller linear dimensions were measured with callipers, the larger with tape-line. Measurements taken from Dr. Warren's memoir and not verified, are marked with an asterisk (\*): it should be stated that some other dimensions given in the same work were proved, by comparison with the bones, to be too great.

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\* The lacking bones of that skeleton are: a few heads of ribs; all sternal segments except the first; all caudal vertebræ except the first seven, the twelfth and the fourteenth; the epiphysis of the superior angle of the right scapula; all the ungual phalanges, and one other phalangeal bone.

† The Mastodon Giganteus of North America. By John C. Warren, M. D. Boston, 1852: Quarto. pp. 219, plates 26.

## CRANIUM.

	Cohoes Skeleton. Inches.	Warren Skeleton. Inches.
Length from parietal ridge to alveolar margin .....	44 $\frac{1}{2}$	48*
Height of parieto-occipital plane .....	19 $\frac{1}{2}$	22*
Width do .....	28 $\frac{1}{4}$	32*
Width across alveoli .....	33 $\frac{1}{4}$	
Diameter of nasal orifice .....	11 $\frac{3}{8}$	12*
Width of occipital condyles .....	8 $\frac{7}{8}$	
External length of tusk .....	35	104*
Estimated external length of tusk before fracture .....	55	
Circumference of tusk .....	18 $\frac{1}{4}$	
Antero-posterior diameter of brain cavity .....		9 $\frac{1}{2}$
Vertical do do .....		5 $\frac{5}{8}$
Transverse do do .....		10 $\frac{3}{8}$
Angle made by parietal and occipital planes at the parietal ridge: .....C. S., 88°—W. S., 90°		
Comparative bulk, without tusks: ..C. S., 1 to W. S., 1.39		

## JAW.

Width across condyloid processes .....	22 $\frac{1}{4}$	
Length of condyle .....	4 $\frac{7}{8}$	6*
Width at 6th molar .....	15	
Width of gutter .....	1 $\frac{1}{4}$	3 $\frac{1}{2}$ *
do tusk area .....	1 $\frac{1}{4}$	3*
Depth of do .....	2 $\frac{1}{2}$	

	Right.	Left.
Width of body at 6th molar .....	3 $\frac{5}{8}$	5 $\frac{1}{2}$
do 5th do .....	4 $\frac{5}{8}$	4
Depth of body inside of 3-ridged molar .....	4 $\frac{1}{2}$	6 $\frac{1}{2}$
Back of 3-ridged molar to front of symphysis .....	14	13 $\frac{1}{4}$
Small spine behind dental groove to front of symphysis ....	18 $\frac{1}{2}$	19 $\frac{7}{8}$
Elevation above supporting table of		
anterior cusp of 3-ridged molar .....	5 $\frac{3}{8}$	8 $\frac{1}{4}$
posterior do .....	6 $\frac{1}{4}$	8 $\frac{3}{8}$

## AXIS.

Width of anterior articular surface .....	5 $\frac{1}{4}$
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## FOURTH DORSAL VERTEBRA.

Length of centrum or body .....	2 $\frac{1}{4}$	3
Width do .....	4 $\frac{1}{2}$	6 $\frac{1}{2}$
Depth do .....	4 $\frac{1}{4}$	
Length from top of spine to base of centrum .....	22	27 $\frac{1}{4}$
Width across lateral processes .....	11	13
Circumference of middle of spine .....	5 $\frac{5}{8}$	6 $\frac{1}{4}$
Height of neural arch .....	1 $\frac{1}{4}$	
Width do .....	1 $\frac{1}{4}$	
Relative bulk .....	1 to 1.90	

## SACRUM.

	Cohoes Skeleton. Inches.	Warren Skeleton. Inches.
Length inferiorly.....	16 $\frac{1}{2}$	20*
Width of anterior articular surface.....	5 $\frac{1}{4}$	7*
Relative bulk.....	1 to 1.94	

## FIRST RIB.

Length.....	24 $\frac{1}{8}$	26
Circumference at middle.....	6 $\frac{1}{4}$	6 $\frac{1}{2}$
Relative bulk.....	1 to 1.18	

## NINTH RIB.

Length, following curve.....	50 $\frac{1}{4}$	55
Circumference at middle.....	4	4 $\frac{7}{8}$
Relative bulk.....	1 to 1.61	

## STERNAL SEGMENT.

Length.....	4 $\frac{1}{2}$	
Depth.....	4 $\frac{1}{4}$	
Width at middle.....	2 $\frac{1}{2}$	
do ends.....	3	

## PELVIS.

Width across spines of ilia.....	65	72
Height from chest of ilium to isciatic spines.....	46	53
Top of symphysis pubis to bottom of ischium.....	20 $\frac{3}{4}$	22 $\frac{1}{2}$
Width of aperture.....	18	21*
Depth, from symphysis pubis to fronts of sacral vertebræ.....	20 $\frac{1}{2}$ 16 $\frac{1}{4}$ 14	21(?)*
From spine of ilium to aperture.....	25 $\frac{1}{2}$	26 $\frac{1}{4}$
Least circumference of pubis.....	10 $\frac{1}{4}$	11 $\frac{1}{4}$
Vertical diameter of thyroid foramen.....	7 $\frac{3}{4}$	9
Transverse do.....	4 $\frac{1}{2}$	4 $\frac{1}{4}$
Relative bulk.....	1 to 1.40	

## SCAPULA.

Superior angle to anterior margins of glenoid cavity.....	32 $\frac{1}{2}$	
Same dimension, exclusive of epiphysis.....	30 $\frac{1}{4}$	33 $\frac{1}{4}$
Superior angle to anterior angle.....	32	36
Posterior angle to anterior margin of glenoid cavity.....	25	30
Width of curved process.....	10 $\frac{1}{2}$	10 $\frac{1}{2}$
Elevation of curved process above body.....	8 $\frac{1}{2}$	
Circumference, neck of glenoid cavity.....	20	26*
Dimensions of glenoid cavity.....	8 $\times$ 5 $\frac{1}{2}$	
Area of glenoid cavity, in square inches.....	31.7	
Relative bulk.....	1 to 1.48	

## HUMERUS.

Length to top of articular surface.....	34	38
Circumference at top.....	33 $\frac{1}{2}$	40 $\frac{1}{4}$
do middle.....	15 $\frac{3}{8}$	18 $\frac{3}{8}$
do bottom.....	22 $\frac{1}{4}$	27 $\frac{1}{4}$

	Cohoes Skeleton. Inches.	Warren Skeleton. Inches.
Length of lower tuberosity.....	12½	13½
do upper articular surface (tape).....	12	14
do lower do do .....	8½	9½
Width do do .....	8¼	
do upper do .....	6½	7
Relative bulk .....	1 to 1.61	

## ULNA.

Length .....	30	33¼
Circumference at top.....	34¼	42¼
do middle.....	13½	15
do bottom.....	21¼	26¾
do neck of olecranon .....	17	20¼
Width of upper articular surface.....	8¼	9½
Longer diameter of head of olecranon .....	8¼	10½
Relative bulk .....	1 to 1.59	

## RADIUS.

Length .....	27	27¼
Circumference at lower head .....	17	
Least circumference .....	6⅛	6½
Dimensions of upper articulation.....	4½ × 2¾	
Width of lower do .....	4¾	5
Relative bulk .....	1 to 1.23	

## RADIUS AND ULNA.

Circumference at lower heads.....	28	34¼
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## FORE FOOT.

Length of cuneiforme.....	6¼	8
do lunare.....	5⅝	6
do pisiforme .....	4¾	5¾
Width of unciforme at top front.....	4¾	6¾
do os magnum do .....	3	3⅞
Length of first middle phalangeal bone.....	3⅞	3⅞
Relative bulk.....	1 to 1.40	

## FEMUR.

Length.....	41½	45
Circumference about trochanter and shaft.....	27¼	31⅝
do at middle of shaft.....	15¼	16¼
do of head.....	19½	22¼
Area of head in square inches.....	33	41¼
Diameter across trochanter and shaft .....	10¼	12¼
do at middle of shaft, greater .....	6	6½
do do less.....	3¾	3¼
Length of inner condyle (tape).....	9½	
do outer do .....	7	8¼
do patellar articulation (tape) .....	5¼	7
Width of condyles .....	9¼	9¾
Relative bulk.....	1 to 1.38	

	Cohoes Skeleton. Inches.	Warren Skeleton. Inches.
PATELLA.		
Length of articular surface .....	4 $\frac{1}{4}$	6
Width do .....	4 $\frac{3}{8}$	6
Horizontal circumference.....	12 $\frac{5}{8}$	16
Relative bulk.....	1 to 2.25	

TIBIA.		
Length .....	26	28
Circumference at top.....	26	29
do middle.....	12 $\frac{1}{4}$	13
Relative bulk.....	1 to 1.22	

FIBULA.		
Length, without upper epiphysis.....	22 $\frac{1}{4}$	23 $\frac{1}{2}$
Circumference at middle.....	5 $\frac{1}{4}$	6 $\frac{7}{8}$
Relative bulk.....	1 to 1.78	

HIND FOOT.		
Length of os calcis.....	7 $\frac{3}{4}$	9
Width of astragalus.....	6 $\frac{3}{4}$	7 $\frac{1}{2}$
Width of anterior face of naviculare .....	5 $\frac{3}{8}$	6 $\frac{3}{8}$
Relative bulk.....	1 to 1.41	

## SUMMARY OF RELATIVE BULKS OR SOLIDITIES.

The table gives the bulks of bones of the Warren Skeleton in terms of the corresponding bones of the Cohoes.

First Rib.....	1.18
Tibia .....	1.22
Radius .....	1.23
Femur .....	1.38
Cranium .....	1.39*
Pelvis.....	1.40
Fore Foot.....	1.40
Hind Foot.....	1.41
Scapula .....	1.48
Ulna.....	1.59
Humerus.....	1.61
Ninth Rib.....	1.61
Fibula .....	1.78
Fourth Dorsal Vertebra .....	1.90
Sacrum .....	1.94*
Patella.....	2.25
Average.....	1.55

\* Computed from measurements given by Dr. Warren.

## GENERAL DIMENSIONS OF THE COHOES SKELETON AS MOUNTED.

	Feet. Inches.	
Length in a direct line.....	14	3
Length following the curve of the spinal column.....	20	6
Width of the thorax at the 7th rib.....	3	5½
Elevation of the crest of the scapula.....	8	4
Elevation of the crest of the pelvis.....	8	4
Elevation of the head.....	8	11
Elevation of the spine of the 2d dorsal vertebra.....	8	10
Elevation of the spine of the 8th dorsal vertebra.....	9	3

## GENERAL NOTES REGARDING THE SKELETON.

HEAD—JAW.—The entire distortion of the head before alluded to, may be due to the non-appearance of the sixth right molar tooth of the lower jaw. The left ramus is entire and appears to be normally shaped. It bears in position the fifth and sixth molars. In front is a surface an inch and one-half square, that indicates the place of the socket (now entirely filled) of the fourth molar. The body of the right ramus is a half inch shorter than that of the left; at the middle it is an inch and one-half less in depth. The 3-ridged molar (its only tooth), is not so far advanced as that on the left side by an inch; it inclines forward about 30°, so that its anterior cusp is raised only three-fourths of an inch above the bone, and is three inches and three-eighths lower than its mate (?) on the left side. The right ramus is seven-eighths of an inch broader than the left at the fifth (?) molar; and as much narrower at the point where the sixth should appear. There is no indication that the sixth molar was ever cut, and there is not now sufficient space between the existing molar and the posterior limit of the dental field for a full sized sixth. There is no vestige of the deserted socket of a fourth right molar. The ridge that anteriorly forms the margin of the gutter of the symphysis, and which in its backward course divides, to form the inner and outer margins of the dental groove, encloses in this case only a very small oblique triangular area before the molar. It is at least fair to presume, either that the fifth had lacked an antecedent molar longer than its mate on the left side, or that the fourth is present and the fifth never appeared. The latter idea is favored by the difference in the size of the two 3-ridged molars of the jaw. The one in doubt, is one-eighth of an inch narrower and one-fourth of an inch shorter than the other, and Dr. Warren makes no distinction between the fifth and fourth molars other than that of size (pp.



67, 68.) The foramina of the right side are smaller than those of the left, and exhibit in their proportions a lack of symmetry directly dependent on the general inequalities of form. Just in front of the left posterior mental foramen is a marked, saucer-like depression that does not appear on the right. The inner face of the right, and outer face of the left coronoid processes and portions of the condyloid, are exceptionally rough; this may be a diseased condition, or more probably due to some dissolving agency acting from the direction in which they face—an agency that entirely removed the right condyle.

**SKULL.**—The buccal ridge upon the right side is very prominent, but on the left nearly obliterated. On the right it divides before the fifth molar so as to enclose a vacant, quadrilateral area ( $3 \times 2\frac{1}{2}$  inches), which displays a marked trace of a tooth socket. The left ridge does not define an area before the molar, but indicates a termination of the dental groove two inches in advance. The palate bones are unsymmetrical anteriorly, the left being twice as broad as the right; and the right articulation for styloid process is half an inch in advance of the left. The left tusk is somewhat the larger and has a different direction. In mounting it, a position too much at variance was given by the warped insertion. Its fragmental condition left the shape of the inserted portion the only guide for position, and it proved untrustworthy.

The projections, upon the medial plane of the skull, of the grinding surfaces of the two sides make with each other an angle of  $26^\circ$ . The front of the fifth left molar is two inches and eight-tenths above the right, and the back of the sixth left, about three inches and eight-tenths below the right. Supposing the left side normal, the right dental row had dropped down anteriorly in search of antagonism, and been retained behind by a process of the palate bone.

**COMPARISONS.**—The Warren Mastodon, by virtue of its nearly complete condition and excellent preservation, of its maturity and great size, and of the scientific description it has received, is entitled to rank as the representative and standard specimen of the species. For this reason, the dimensions of the Cohoes skeleton are contrasted above with those of the Warren, and it is deemed proper to describe some of the individual peculiarities of the one by a comparison with the other. In height our skeleton is ten per cent. less than the Warren; clothed in flesh, they were respec-

tively about nine and one-half and ten and one-half feet high at the shoulders. If this ratio were applicable to all other dimensions, their weights would be estimated to bear the ratio of three to four, but other considerations make it probable that the difference was considerably greater. The larger animal was by far by the more robust and muscular; the trochanters are more than proportionally larger, and all processes and surfaces for the attachment of muscles are of greater size and more rugose, while the patella is more than twice as large. An inspection of the dimensions, already given of leg bones, reveals the fact that those of the Cohoes skeleton are comparatively slender.

In the following table the ratios in the first column are obtained by dividing the lengths of bones of the larger skeleton by corresponding lengths of the smaller. In the second column, are average ratios of several different circumferences of each bone. The third column gives the comparative bulks or solidities obtained by multiplying the ratios of the first column by the squares of those of the second. The fourth gives the comparative stoutness, or the ratio between cross sections after eliminating the difference due to difference of length; it is obtained by squaring the quotient resulting from the division of a number of the second column by one of the first.

(The Cohoes skeleton is in each case the unit with which the Warren skeleton is compared.)

	Ratio Length.	Ratio Circumference.	Ratio Bulk.	Ratio Stoutness.
Humerus .....	1.12	1.19	1.59	
Ulna .....	1.12	1.20	1.61	
Average for Fore Leg .....	1.12	1.19½	1.60	1.14
Femur .....	1.08	1.13	1.38	
Tibia .....	1.04	1.09	1.22	
Average for Hind Leg .....	1.06	1.11	1.30	1.09½

That is, the fore leg of the Warren Mastodon is fourteen per cent. "heavier built" than that of the Cohoes, and the hind leg,

nine and one-half per cent. As the former bore tusks of very great weight, it is natural to infer a correlation between their development and the exceptional strength of the fore legs. The proportions of the Cambridge Mastodon and Elephant Pizarro, are in accordance with the idea, but the data at hand do not warrant its confident proposition. So long as the Warren Mastodon is alone in showing a preponderance of strength in the fore legs, we cannot be sure that it is not an individual variation.

The Cambridge skeleton was shown by a similar comparison to be as stoutly built as the Cohoes, and twenty-three per cent stouter than the Elephant Pizarro.

MINOR ANATOMICAL PECULIARITIES.—The twentieth right rib differs from all others except the first, in having an articular surface on the neck. It is, moreover, abnormally short, and its distal end is enlarged so as to form a sort of knob.

The trapezoides, which in the Warren and Baltimore skeleton, is sub-cubical and entire, is in the right foot of the Cohoes divided by an articulation into two unequal bones, of which the greater, in the form of an **L**, partially encloses the less: the corresponding part of the left foot was not found.

The scaphoides, as well as the trapezoides, offers an articular surface to the trapezium. Dr. Warren describes and figures the latter as touching the trapezoides only, in his skeleton.

STERNUM.—Material is as yet wanting for a full description of the sternum of *Mastodon giganteus*. The number even of the segments is in doubt, though analogy indicates five, the number in *M. longirostris* (E. Sismondi, cited by Dr. Warren, p. 199), and in the modern species of Elephant.

The Warren skeleton exhibits the first member only, and the Cohoes possesses a segment of somewhat doubtful position, but probably the second, and so placed in articulation. The form of the latter is irregularly sphenoid, the inferior face being the narrowest. The superior face is four and one-fourth inches long and about half as broad, but not distinctly limited at the sides; longitudinally it is slightly concave, and transversely, plane in the middle, but at the sides convex and confluent with the lateral faces. The lateral face is a little shorter than the superior, and measures four and one-fourth inches in height at the middle. Its inferior margin is convex in outline, especially toward the pos-

terior end, and its surface is vertically convex—so as to give a sub-ovate transverse section to the bone—and longitudinally concave, reducing the transverse diameter of the segment from three inches at the ends to two and one-half at the middle. The terminal faces are ovate and quite convex, and have the porous papillose surface characterizing cartilaginous attachment. A comparison of the dimensions of this bone with those of its equivalent in *M. longirostris* (taken from Dr. Warren's translation of Prof. Sismondi's description), shows that the proportions were very different in the two species.

	<i>M. giganteus.</i> Inches.	<i>M. longirostris</i> Inches.
Length of second sternebra.....	4.5	6.3
Width.....	3.	4.3
Depth of anterior margin.....	4.	1.9

As there remains some doubt as to the ordinal position of the bone just described, a detailed comparison is not warranted; but it seems beyond question that while the sternum of *M. longirostris* is broader than deep and but slightly carinated, that of *M. giganteus* is decidedly cariniform.

SEX.—Size, development of tusks, the presence or absence of mandibular tusks, and the diameter of the pelvic aperture, are all characters aiding in the determination of sex in the Mastodon. While no one of them can be regarded as of crucial authority, their concurrent verdict leaves little room for doubt. The Warren Mastodon, of maximum size, supporting unusually long and large tusks, armed with an inferior canine tooth, and exhibiting a comparatively small pelvic aperture, is incontestably a male. The Cambridge skeleton on the other hand, very much smaller than the last, though nearly as old, furnished with short and slender tusks above and none below, and with a pelvic aperture large as compared to other dimensions, is a female. The Cohoes skeleton, while of the same age as the Cambridge, is in size intermediate between the others. Its tusks nearly equal those of the Warren skeleton in diameter, but are far shorter. The evidence as to mandibular tusks is somewhat ambiguous, but two appear to have been shed, the sockets of which are nearly filled by osseous matter; the "truncated" area of the jaw measures two and one-half inches vertically, by two and three-fourths laterally. The aperture of the pelvis is even smaller in proportion than that of the Warren; and, on the whole, the indication is very decided that it is a

male skeleton. As the question of the value of pelvic measurements in determining the sex of proboscideans is of some importance, the data at hand are here tabulated, the width of aperture being contrasted with the extreme expansion of the ilia, and also with the length of the femur.

	Length of Femur.	Width of Pelvis.	Width of Pelvic Aperture.	Ratio of Aperture to Femur.	Ratio of Aperture to Pelvis.	Mean of the two Ratios.
Cambridge Mastodon .....	36*	58*	18*	.527	.327	.43
Warren Mastodon .....	45	72†	21*	.466	.291	.38
Cohoes Mastodon .....	41 $\frac{1}{2}$	65	18	.433	.277	.36 $\frac{1}{2}$
Elephant Pizarro (male.) .....	41*	43*	16*	.390	.372	.38
Albany Elephant (male.) .....	41	41	12 $\frac{3}{4}$	.311	.311	.31

\* Measurements taken from Dr. Warren's memoir.

† Dr. Warren gives 74.

AGE.—An examination of the molar teeth and epiphyses of different skeletons affords good data for an estimate of their comparative age. In regard to the succession of teeth, the three skeletons examined exhibit the same stage, that of the presence of the fifth and sixth molars above and below. In the Cohoes and Cambridge skeletons the sixth molars are not worn, and the fifth but slightly; in the Warren skeleton the wear has advanced a little farther, but no cusp of an ultimate molar is so worn as to be terminated by a plane half an inch in width. As to the coalescence of the epiphyses, there is more difference; those of the humerus, radius, ulna, pelvis, femur, tibia and fibula, and some others are coössified in the Warren skeleton and not in the Cohoes and Cambridge. It follows that the Cohoes Mastodon attained the same age as the Cambridge, and was but slightly exceeded by the Warren. He had but commenced to use his final and largest grinders, and had attained nearly or quite his full growth. It is also evident that the period of maturity—of the coalescence of the great epiphyses—is during the first wear of the sixth molar, and before the shedding of the fifth.

It is worthy of remark that four of the five elephantoid skeletons here compared, bear witness to the diseases or accidents of the living animals. The Warren Mastodon has an exostosis on

the jaw and had sustained a fracture of the ribs; the Elephant Pizarro had broken his leg (femur); the Albany Elephant had fractured the ilium; and the dental difficulties of the Cohoes Mastodon may have prevented a more robust development.

ANALYSIS.—A qualitative analysis of the ivory from a tusk of the Cohoes Mastodon, by Mr. E. J. Weeks, now of Jackson, Mich., showed phosphate and carbonate of lime, sesquioxide of iron, and a trace of chloride of sodium.

#### THE ULSTER COUNTY MASTODON REMAINS.

There are in the Museum some Mastodon remains from Ulster County, N. Y. (see Cabinet Report XIV), consisting of an imperfect skull retaining the last molars, a part of the lower jaw with the corresponding molars, a part of the femur, and some other bones in an imperfect condition.

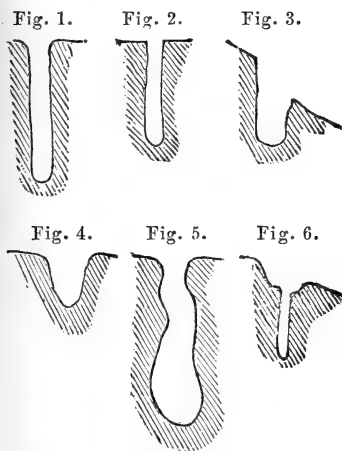
The skull is as long as that of the Cohoes skeleton and three inches broader. Its ultimate and only molars are of the same length with the Cohoes, and one-fourth of an inch broader. Each of them is so worn, excepting a small portion at the rear, as to present a broad, concave area of dentine, bordered by a simple rim of vertical enamel. The interior cavity of the tooth, which Dr. Warren was lead to suppose filled in old age by successive deposits of dentine (*Mastodon giganteus*, p. 69), is here exposed and open. The inferior molars are less worn, and, like the superior, are advanced to the front of the dental groove. The tusk sockets measure in diameter—right six inches and one-fourth, left, six inches and three-fourths. The articular surface for the jaw is not in the glenoid cavity but one inch and one-half in advance upon the zygomatic ridge, showing that the jaw had come to occupy permanently a position that in its normal condition was only occasionally assumed.

The diameter of the femur head is six inches and sixty-five hundredths, which gives for its area 34.74 square inches—a trifle more than in the Cohoes skeleton.

The single tusk accompanying the parts enumerated, has a length of six and one-half feet, and a circumference of twenty-one inches.

NOTES OF INVESTIGATIONS AT COHOES WITH REFERENCE TO THE CIRCUMSTANCES OF THE DEPOSITION OF THE SKELETON OF MASTODON;  
BY G. K. GILBERT, UNDER THE DIRECTION OF JAMES HALL.

**POT-HOLES.**—The pot-holes of the river bed exhibit all stages of formation and obliteration. The shales of the Hudson River Group present everywhere a surface quite rough in detail, though even and regular in its general features. An insensible gradation may be seen above the crest of the fall, from irregular hollows bounded by sharp fractures of slate, to deep, rounded, smoothed pot-holes. Upon the plateau below the fall the few remaining pot-holes are filled nearly to the brim by gravel and mud, and are gradually disappearing as the surface of the surrounding rock is lowered by wearing without any corresponding wear in the bottom of the cavity. The typical form of these pot-holes is a cylinder with rounded bottom and rounded brim like a chemist's test-tube (fig. 1.) Where the river bed is undergoing erosion the brim



often becomes angular (fig. 2); and upon the fall one margin is frequently much depressed (fig. 3). The type is modified in some shallow pot-holes by an enlargement of the mouth (fig. 4), and in some deep ones by expansions and constrictions in the shaft (fig. 5), the greatest expansion being generally at the bottom. The union of several holes gives rise to many irregular forms, and any very decided departure from a circular cross-section may be attributed to this cause.

In a few instances the mouth of a slender pot-hole was noticed in the bottom of a broader one (fig. 6). The interior surfaces are rounded, smoothed and even polished, especially toward the bottom. The axis is always vertical or nearly so, and independent of the dip of the strata. In my examination I saw nothing to controvert the theory that they were formed by the grinding action of stones moved by water. The force of the currents within the pot-holes is attested by the fact that some of them of considerable depth were found empty (of aught else than water), while in many a few stones were found. Several of them held so much gravel as to preclude the idea that they are now deepening, and

of these the number is in several ways increased by human agency. Besides the effect of the cultivation of land in the valley of the Mohawk, the volume of the river is seriously diminished, in the part examined, by the dam and races of the Cohoes Company. Moreover, a dam of this company was carried away in 1846, and an immense amount of gravel used in its construction was strewn over the river bed.

Of 350 pot-holes examined above the fall,

1	is	7	times as deep as it is broad at top.
3	are	8	times as deep as they are broad at top.
9	are	6	do do do
7	are	5	do do do
14	are	4	do do do
33	are	3	do do do
56	are	2	do do do

The deepest of this system, No. 180, measures 23 feet, and has a diameter of three feet; eight others show a depth of over ten feet. If the gravel with which, from causes above referred to, many have been filled, were removed, the above figures would need amendment. The pot-holes upon the crest of the fall and partly down the declivity appear to be, and, I think, are deeper than those farther up; but the latter are so generally cumbered by gravel that their full depths cannot be measured. The situations first freed from superfluous gravel are probably those of the deepest holes.

The basin under the fall contains a few large pot-holes, but is in large part conformable in its outlines to the strike of the strata. Its deepest pot-hole measures 49 feet below the plateau and 25 feet below the adjoining channel. In another place a sounding of 25 feet is surrounded by soundings of 15 feet. The summer channel of the river for a half mile below the fall is through a series of large, connected pot-holes. Soundings show a very uneven bottom, and many scollops of the margin are unmistakably brims of pot-holes. Below the fall nearly all pot-holes are in the immediate neighborhood of the channel, and there are few small ones.\* The only exception observed is in the case of a group at the mouth of a rivulet entering just below the Cataract House. In the summer of 1867 I noticed there a broad concavity in the plateau, but could not ascertain its depth or character. The

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\* This remark applies to the region shown in the map; a little further down, the channel ramifies, and pot-holes can be found nearly across the bed.



floods of the following spring washed away the *debris* that then covered a group of smaller holes (one to three feet in diameter), situated six or eight feet above the plateau, in the notch where the stream enters. This notch indents the cliff so deeply as to afford an easy descent to its base. It now conveys only some leakage of the mill-race, and its proper stream is so entirely cut off by canals and roads that it is even doubtful with what notch in the clay hill it was originally connected. The exceptional position of these holes suggests that they were formed by the stream that cut the notch. The last, however, has the form and dimensions of the valley of a very small stream, and I have yet no other evidence of the formation of pot-holes by small streams. The large depression may be the bottom of an ancient pot-hole.

PLATEAUX.—A striking peculiarity of the river bed is its evenness—not in the space of a few feet, but when a broad area is considered. The flood-plain of a river freshly upturned by the plow affords a comparison. Exclusive of pot-holes, the greatest depressions and elevations vary but a few inches from the general level,\* and this level does not sensibly vary in the width of the river bed. I ascertained that at a point near the fall it is  $1\frac{1}{10}$  feet higher than at a point 480 feet further down stream—the rate of fall of the stream. All the features of this floor indicate that it depends, like a flood-plain, upon the water level, with the difference that it indicates a minimum, instead of a maximum stage of water. In summer it is now bared; but, on Sundays, when less water is taken from the river by the mill races, its hollows are flooded, and I am confident that the natural summer stage would just cover it. The jagged detail of this surface forbids the theory that it is caused by wearing of water or of materials moved by water. I conceive that the upper mass of rock has been disintegrated by frost and removed by the current down to the limit of perpetual protection by water. This floor characterizes the bed of the river from the basin of the fall down to the rift above the bridge of the

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\* Exception must be made of an oval hill—about  $75 \times 35$  feet, and rising 5 8-10 feet above the plateau—which adjoins the basin a little west of the channel. Its upper end is some — feet from the base of the fall. Wet by spray half the year, exposed to the blows of ice blocks just from the fall, washed clean by every flood, its endurance is difficult to comprehend. Its greatest elevation above the plateau was carefully noted, with the thought that another observation, ten years hence, might show some alteration. The standard of comparison, however, may be undergoing alteration. A natural result of the lessening by human agency of the minimum volume of the Mohawk, would be a gradual disintegration and lowering of the surface of the plateau.

Rensselaer and Saratoga railroad—nearly three-fourths of a mile—and, above the fall, from the upper limit of the pot-hole district to the dam of the Cohoes company, above which point the depth of the water prevented an examination. Over considerable portions of these areas there are no pot-holes. For a half mile below the fall the pot-holes are confined to the channel, having here an average width of less than 100 feet, while the river bed is 800 feet broad. The plateau on each side varies from 300 feet to 400 feet in width and is terminated (with unimportant exceptions) by a precipitous cliff. There is reason to believe that the river at this point has not always maintained its present width. The great depth of the summer channel indicates that the base of the fall has, during its recession, been nearly as low as it is now; but no vestige remains of the previous basin of a broad fall like the present. The recession of the cliff (considered on another page) readily accounts for the formation of a broad bed after the passage of the receding fall. This hypothesis, according with nearly all the present phenomena, seemed controverted by the question—how came about the sudden widening of the cataract, from 100 or 150 feet to 950 feet, in a homogeneous rock? I think, however, an answer was furnished by the discovery of a cluster of large ancient pot-holes at the eastern end of the fall. We have only to postulate an extension of this series across the line of the present fall-basin, and the needed lessening of the resistance of the rock is attained. The broader fall would recede less rapidly than the narrower, and afford time for the excavation of the present width of gorge.

LAKE.—The “lake” (a title applicable only in summer to a part of the river above the fall) is drained in summer by several small streams that many times unite and divide in passing to the brink of the fall, but wash, on their way, most of the deeper pot-holes. One of these streams is at present decidedly larger than the others, and must, I think, not only maintain, but increase its superiority, so as to comprise, first the summer flow, and finally the entire body of the river, reducing it in a few centuries or scores of centuries to a condition analogous to the present state of the lower Portage fall, and ultimately leaving only a transverse row of pot-holes to mark the abnormal width of Cohoes Falls.

I have no hypothesis to offer for the origin of the lake. A

glance at the map shows that its margins conform largely to the strike of the strata. The soundings disclose rocky bottom shelving easily toward all shores but the eastern, where two or three large pot-holes, probably of the ancient system, increase the soundings to over 20, and in one spot to 31 feet. If it were the ancient basin of a low fall that has now completed its work, one would expect to find in its bottom such irregularities as characterize the basin and channel below the present fall.

**BED ROCK.**—The rock over which the Mohawk flows, from the Cohoes company's dam to the Hudson, is of very uniform character. The shaly strata dip from  $45^{\circ}$  to  $70^{\circ}$  toward the S. E., and their strike is generally N.  $30^{\circ}$  E. The same uniformity holds for some distance above the dam, but near Crescent compact layers of conglomerate are intercalated.

**ANCIENT POT-HOLES.**—Excavation has revealed in Cohoes and its vicinity a number of pot-holes formed anterior to the present gorge of the Mohawk.\* I have noticed six besides the large one in that immediate neighborhood. Near the chimney of the new mill a pot-hole 15 feet broad and at least 20 deep, was opened in cutting a race for the water discharged from the new mill. I saw in the same cut eight other pot-holes,—none over five feet in diameter, and two of them less than one foot. The cutting for the south end of the railroad bridge shows a deep pot-hole, and a half dozen appear between this and the tow bridge of the Champlain canal. I was informed by Mr. Van Auken that pot-holes were found in grading for the block of houses north of the new mill, and in excavating the mill-race near the falls. There are cross-sections of two in the overflow of the race above the Cataract House, and between the Cataract House and School street, are two marshy spots that probably mark large ones. Above the falls, at a distance of from 200 to 300 feet, and as far west from the river-bank, are four or five depressions indicating pot-holes of from five to ten feet diameter. The margin of one, eight feet across, is well marked. East of the river are a number of small marshes and pools that are determined as pot-holes by the following characteristics. They are circular or sub-circular. Though surrounded by rock in place, covered by only a few

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\* Of the group in which the Mastodon was found, Mr. Whitfield has made measurements and memoranda, which are communicated in an accompanying diagram.

inches of crumbled shale, they contain a depth of soft mud; one was probed seven and one-half feet, and another ten feet without reaching bottom. They have no outlets. No trees or stumps stand in them, and those on their margins lean toward them. Eight of them are near the end of the fall, and have the following diameters:  $15 \times 15$ ,  $123 \times 52$ ,  $48 \times 30$ ,  $15 \times 15$ ,  $35 \times 25$ ,  $30 \times 20$ ,  $20 \times 20$  and  $15 \times 20$  feet. Four hundred feet to the N. E. are three others measuring  $10 \times 15$ ,  $40 \times 35$  and  $10 \times 15$  feet. Five hundred feet north of the fall, close to the cliff, are two more, respectively 10 and 15 feet across. Near by are two larger swamps that probably cover pot-holes, but their shapes are not sufficiently symmetrical to give assurance of the fact.\*

The great difference between the pot-holes of the shore and of the river bed appears to be that of size. Half of those discovered on the eastern shore outrank the largest of the modern. The Mastodon pot-hole was probed to a depth greater than the river bed can show, and if the pot-holes of the upper basin belong, as I surmise, to the ancient system, their depth was 70 or 80 feet. Mr. Whitfield saw a section of pot-hole in the form of a Florence flask. Of the six or eight sections that I have seen, none have approached this shape, and, although my attention has been directed to the matter, I have observed nothing of the sort in any modern pot-hole. A number are expanded at bottom, but not to exceed double the diameter at top. The gravel from the ancient pot-holes is all well rounded, while the modern ones contain many boulders that are but partly so. I think, however, that this difference is entirely due to the recent influx of gravel received by the latter. The modern holes contain, besides the hard erratics, slightly worn fragments of the surrounding shale.

CLIFFS.—The cliffs of the river gorge are in some places now receding. The river prevents the accumulation of a natural talus on the east side from the company's dam to the railroad bridge, and, on the west side, from the fall to the new mill at least. Beyond this, artificial heaps preclude observation. The inclination below the fall ranges from  $60^\circ$  to  $75^\circ$ , and is nearly  $90^\circ$  in a few places. For 600 feet above the fall (east side) the average is at least  $80^\circ$ , and above that from  $55^\circ$  to  $45^\circ$ ; with an even slope, covered in many parts with a mixed vegetation down to high-

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\* See Note C.

water line.\* For a space of five rods above and as much below the fall there is no vegetation; the weight of frozen spray may have uprooted such plants as have obtained foot-hold. From the upper limit of this barren space to a promontory 500 feet further up, the existing plants are dwarfed, contorted cedars, appearing at a

Fig. 7.



little distance mere bushes, but really very old trees. The roots crowd into the crevices of the shale without any soil; and, without exception, have been partially bared by the waste of the cliff during the growth of the trees. The older trees hang by long roots from points of support often above their highest branches, and are much contorted and scarred (fig. 7). Climbing from below, or lowered by a rope from above, I have examined nearly all these trees, and measured in each case the circumference of trunk and length of exposed root. I

have also counted the rings of annual accretion of several sections to ascertain the relation of size to age. From these data an idea may be obtained of the rate of recession of the cliff. The growth is exceedingly slow. A branch of one and one-eighth inch in diameter showed 100 rings of growth, and an average of six such branches gave 72 years per inch of diameter. The figures used below were obtained from two sections of *trunks*. One of these (specimen preserved) measures  $19\frac{1}{2}$  inches in circumference, and exhibits 310 rings; the other gave 11 inches and 270 rings. In these an inch of circumference represents 19.1 years, and an inch of diameter, 60 years.

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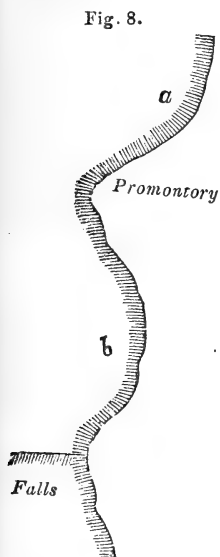
\* See note A.

*Table of Cedar-root Chronology.*

1. Circum. of base of trunk, in inches.	2. Estimated age, in years.	3. Length of exposed root, in inches.	4. Recession of cliff per century, in inches.
11	210	72	34.2
19	363	117	32.2
30	573	150	26.2
16	306	72	23.5
19	363	72	19.8
29	554	108	19.5
6.5	124	24	19.3
7	134	24	17.9
9.5	183	30	16.3
19	363	56	15.4
37.5	716	84	11.5
19	363	38	10.5
6	115	12	10.4
8	153	12	7.8
9	172	12	7
28	535	36	6.7
9.5	183	12	6.5
15	286	9	3.1
7	134	2	1.5
			19 ) 289.3
Average.....			15.2

The rugged nature of the cliff renders the result from a single tree unreliable. If it commenced life in a concavity, its roots may have been but slightly uncovered after the lapse of centuries; while, if it clung to a prominence, a single century's frosts may have disclosed several feet of root. Of the nineteen that I measured, one, aged 210 years, shows 72 inches of root, and another, aged 134 years, but 2 inches. They indicate recession at those points of 34 inches, and  $11\frac{1}{2}$  inch per century. The average rate for all is 15 inches per century. It is presumed that the roots bared had originally run normally into the cliff. If some of them had an oblique direction, the amount, and consequently the rate of recession have been overrated. It is further presumed that the exposed roots have not lengthened since their denudation. If they have done so, our estimate should be reduced. We are safe in saying

that 15 inches per century is not too small an estimate. The portion of cliff on which these grow is now losing ground more rapidly than others. Fifty feet above the promontory alluded to, grasses and other trees than the cedar find foot-hold and show very slight baring of roots. The change at the promontory is note-worthy, as it contrasts two methods of water action. The upper aspect *a* (fig. 8) receives the brunt of the direct wear of the water, assisted by floating ice, etc. The cove *b* is comparatively sheltered from the current, but catches the spray from the fall, and crumbles, under alternating extremes of moisture and of temperature, at the rapid rate given above.\* Below the fall the east cliff is nearly as steep as above, and supports little vegetation. Patches of cedars cling in favored places, and some hemlocks are seen, but about half the escarpment is bare. The west cliff, though

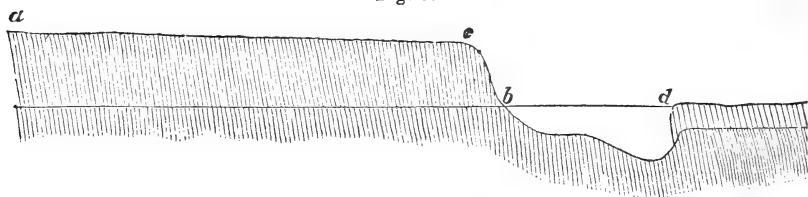


steep, is covered by grasses and mosses, and is losing ground very slowly. A few rods above the new mill an elm tree, with trunk ten inches in diameter, grows on the face of the cliff, without exposure of roots, and in like manner a chestnut (?) of the same size and a cedar eight inches through. The latter is a more thrifty tree than those mentioned above, and probably grew more rapidly. A few rods farther up, at the foot of School street, are a number of thrifty cedars and hemlocks with undisturbed roots. Within a few rods they are contrasted by two hemlocks, about one foot in diameter, growing on the top of the cliff, one of which has been undermined four or five feet, and the other eight. The west shore above the fall is low, of loose material, marshy from the leakage of the race, and now gaining ground rather than losing. In fine, it appears that the maximum present waste of the shore is 15 inches per century, that the greater part of that under consideration is crumbling less rapidly, and that a considerable portion is almost stationary. I deem it proper to allow 12 inches per century as a rate of recession, through a long period, of any portion of cliff. This gives, as the time necessary to have removed the banks below the fall from the deep channel to their present position, 35,000

\* See note A.

years ; which period I consider a minimum for the time that has elapsed since Cohoes Falls were opposite the Mastodon pot-hole.

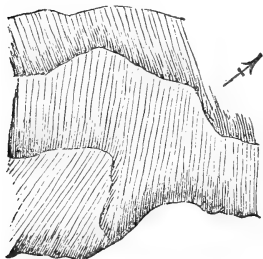
Fig. 9.



**FALLS.**—The water makes no clear leap in Cohoes Falls. The fall (properly speaking) commences at *a* (fig. 9). From *a* to *c*, a distance of 400 feet, the descent is 14 feet ; from *c* (crest) to *b* (base), 57 feet ; making a total of 71 feet. The slope *c b* is a little less steep than the dip of the strata. From *a* to *c* is the region of pot-holes now forming. Most of them must disappear at *c* by the destruction of their walls ; a few of the larger, wearing as rapidly at bottom as at top, are being carried down to take positions in future basins. The slope *a c* displays such rapid erosion, that it has occurred to me that it may be wearing more rapidly than *c b*, and thus converting the cataract into a rapid. Is it not possible that rapids constitute the normal mode of descent of a river over these upturned shales, and the falls are merely an episode occasioned by preëxisting pot-holes ?

**SLIPS.**—All the slips observed strike across the gorge, and dip S. E. at various angles, all less than the inclination of the strata.

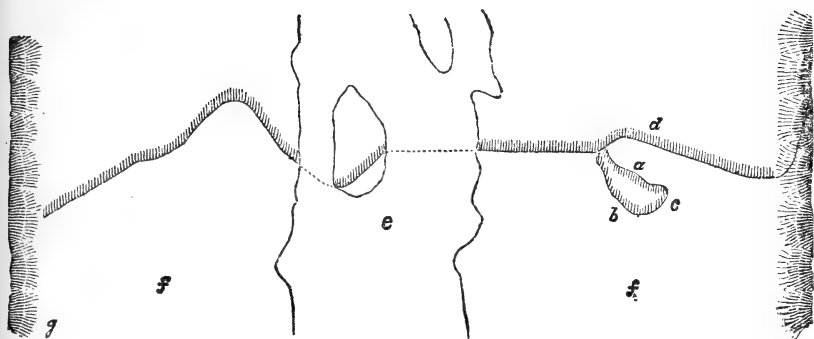
Fig. 10.



West of the channel, opposite the new mill, I observed a combination of three slips in slightly different directions, and separated by quartz (fig. 10). They seem to record three movements along the same fault-plane, with intervals of time sufficient for the deposition of crystalline quartz. Some exposures of surfaces of faults are very finely shown on the plateau, and, if cleaned from river slime, might show the direction of the slide. I have drawn one (fig. 11) that can be traced quite across the river near the mill. While the section given in the cliff *g* is straight (dipping about  $25^{\circ}$ ), that in the plateau *b* is devious. Joining with it is a fault curved in the direction of the movement.

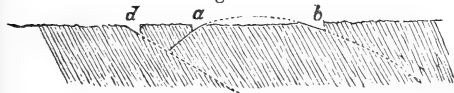


Fig. 11.



At *a* and *b* are striated surfaces dipping from each other, and shown at *c* to be parts of a curved surface. The straight slip *d* dips toward the curved one.

Fig. 12.



A section (fig. 12) makes this plainer. Theory: the direction of motion of the

Fig. 13.

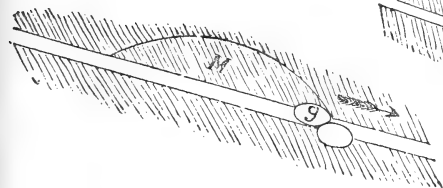
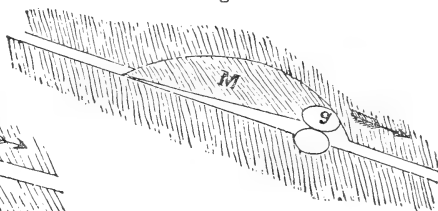


Fig. 14.



upper mass is shown by the arrow (fig. 13). A large concretion at *g* meets another in the bed, and loosens the mass *M*, so that it assumes the position in fig. 14, until the projections pass each other. We might object that so slight a motion seems insufficient to produce the groves of the curved surface.

Above Cohoes town the bed-rock of the west shore is, to a large extent, hidden by hills of drift and a terrace of clay. On the east side, an area nearly a mile broad and two miles long, stretching along the river from the falls toward Middletown, shows the bed-rock, covered by a thin clay soil derived from the decomposition of the rock itself. This area is elevated about 175 feet above the water of the Hudson. Its character is very uniform. It is undulating, and the axis of each hill is due N. and S. Some of the declivities facing E. or W. are steep, but none of those facing N. or S. Its eastern boundary is a line of drift hills and terrace. The latter is of clay covered by sand, and extends eastward to

the Hudson, and some distance up that river.\* In one place a narrow cutting through it and its foundation of drift connects the area described above with a stream flowing toward the Hudson. The drift hills frequently rise above the level of the terrace. Mr. Johnston's house is on a hill of drift a trifle higher than the clay of the terrace. I think the layer of sand, where unblown, is not very thick; one section in the road between Middletown and Waterford shows about five feet.

CHRONOLOGY.—1. The ancient pot-holes, whether formed by glacial or fluvial action, are as old as the present conformation of the surface of the rock. No agency that would permit the existence of the present yielding shores of the Mohawk valley could drill them. If they are not glacial, they are pre-glacial. The surface of the rock was shaped by a force acting due south, and was anterior to the deposition of gravel and clay. 2. The gravel hills are older than the clay. 3. The clay was quietly deposited, and was continued across the Mohawk and Hudson valleys. 4. The absence of lower terraces indicates that in the rising of the land there were no considerable rests. During or after the elevation, the Mohawk cleared its present valley, and chose its bed.

LEVELS.—The rock plateau below Cohoes Falls is the base line for sections near the Falls; it is 61 feet above tide-water.

	Above plateau.	Above tide.
The elevation of the Erie canal above lock 18 is ...	127	188
Upper level of Cohoes Company's race.....	94	155
Cliff near falls.....	115	
Top of clay between Cohoes and Crescent.....	207	268
Top of clay in Greenbush .....		194
Top of sand in Greenbush.....		212
Plateau west of Albany .....		225
Top of gravel hill near "Patroon's," about.....		240
Top of gravel hill near Shakers' road, about.....		325

ROCHESTER POT-HOLES.—The pot-holes in the Niagara limestone at Rochester are generally not so deep as broad, and range from

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\* See p. 141.

one to twelve inches in diameter. The depth of basin below the upper fall is 40-45 feet.

**PITTED ROCK.**—In the channel, at the east side and several hundred feet below the basin of the fall, is a mass of rock in place, ten or fifteen feet long, hollowed out and pitted over its entire surface, as though being dissolved by water. Its texture is that of the concretionary masses. A specimen was collected.

**TERRACES.**—I have recently walked (May, 1868) from the Patroon's up the Shakers' road nearly to the Shakers' settlement, and thence to the Mohawk near Shakers' Island. After the first mile, which was over gravel, I was upon a sand plain varied by hills of blown sand, and did not see the clay, though I crossed several gulleys. In the bed of a stream near the Mohawk I saw gravel, on which the sand seemed to rest immediately. In riding to Saratoga, I saw from the cars that the terrace continues from Waterford to Mechanicsville on both sides of the Hudson. I was unable to obtain another good view until I reached Ballston, from which place to Saratoga the railroad track is laid on a terrace of sand resting on clay, which, Dr. Allen told me, were continuations of the sand and clay of the Albany terrace. With him I examined two sections in Saratoga. One showed

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Fine yellow sand.

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Red clay.

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Dark, coarse, sorted (Laurentian?) sand.

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Fine yellow sand.

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The other, Laurentian gravel, little sorted.

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Red clay.

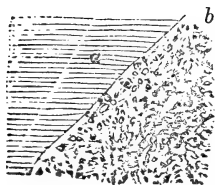
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I made no measurement, but observed that the sand is much deeper and the clay much thinner than in Albany. Dr. A. says blue clay generally underlies the red.

From the Patroon's to the Rural Cemetery I have not observed the clay; from a point not much above the cemetery to Cohoes it can be traced by an observer standing on the hill behind Troy. From this position I detected a sloping southward of the top of the clay terrace, which I was able to verify with a surveyor's level. At a point near the West Troy station of the Rensselaer and Saratoga railroad the clay has nearly its Cohoes level, while it is 25 or 30 feet lower a mile further south. The clay flanks the east bank of the Hudson from Troy to Greenbush.

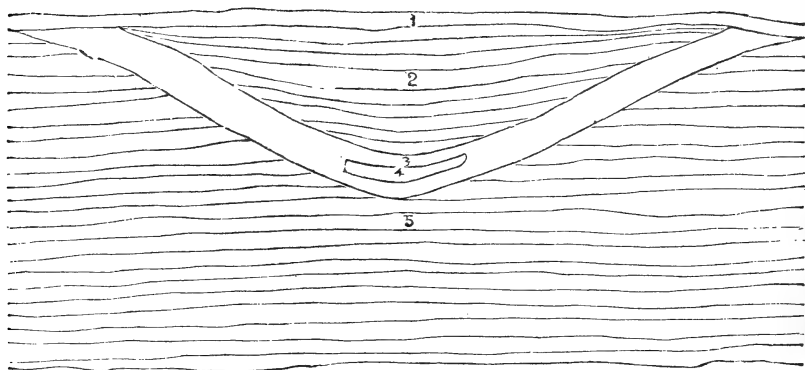
## SECTIONS OF GRAVEL BANKS.

Fig. 15.



In Greenbush I have carefully observed a gravel hill *b* (fig. 15), upon which red clay rests, and against which lies undisturbed, horizontal, laminated, red clay *a*. The locality is one quarter of a mile east from the South Ferry. At the Patroon's a remarkable, inclined bed of clay lies under and over gravel, as shown in fig. 16.

Fig. 16.



1. Soil. 2. Slightly sorted gravel. 3 and 4. Red and blue clay with concretions. (The coloration is independent of the laminae.) 5. Stratified, coarse and fine sands, with rarely lenticular beds of coarse gravel. Beyond this section the hill rises 100 feet higher.

Fig. 17.

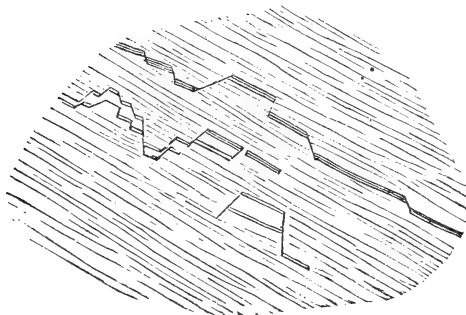


Fig. 17 is a section of a gravel bank near the Patroon's, representing faults in beds of fine and coarse (dark and yellow) sand. The height of the section is five feet. Fig. 18 is a section, six feet in height, from the same locality, also representing

Fig. 18.

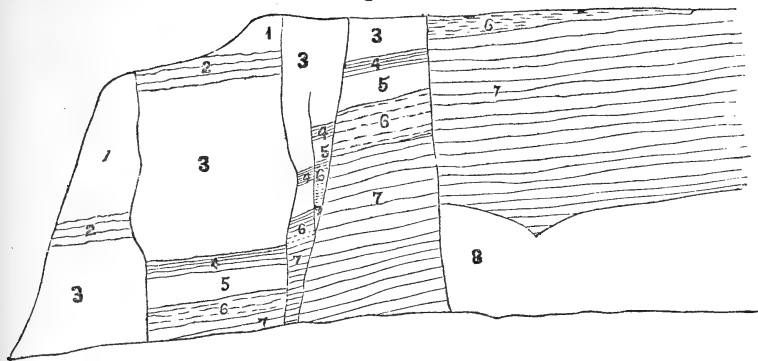


Fig. 19.

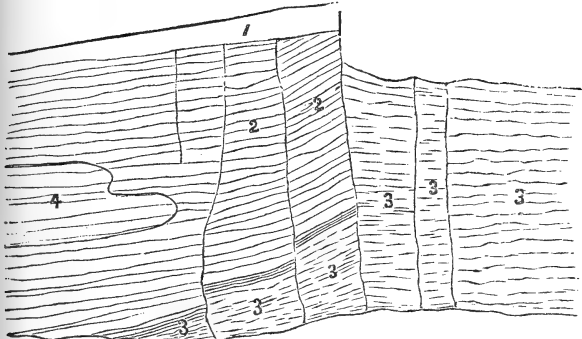


Fig. 20.

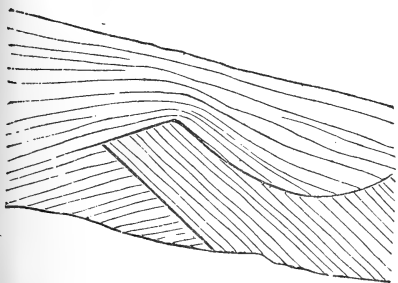
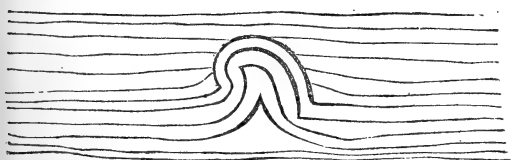


Fig. 21.



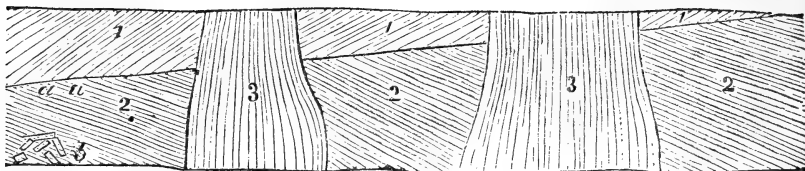
faults in beds of sand. The two are from the bottom of the escarpment. Fig. 19 is a section twenty feet in height, in which 1 indicates soil; 2, yellow clay; 3, coarse sand; 4, blue

clay. In fig. 20 is given a section of gravel and sand, of seventy feet in height, showing discordant stratification. Fig. 21 is a section of a sand bank, illustrating a remarkable contortion of the material. The above are all from the same gravel banks, near the Patroon's,

at North Albany, in the end of a range of drift hills which extend nearly to Cohoes. Perhaps the hill in Waterford belongs to it. The appended section (fig. 22)

is exposed in gravel banks at Waterford.

Fig. 22.



1. Stratified gravel. 2. Stratified gravel. 3. Talus interrupting section. *a a*. At this place the gravel is cemented by carbonate of lime, masses of which have fallen at *b*.

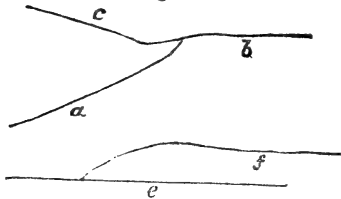
The coarser materials of the gravel hills near Albany are chiefly of the conglomerate of the Hudson river group and conglomerates and jaspers of the Quebec group (as shown in Bald mountain). Massive quartz, white or yellow (Potsdam?), is commonly met with, and in some hills near the Mohawk seem even to predominate. They are the best worn of all the pebbles; but the boulders generally are not so well rounded as those turned by pot-holes.

DRIFT STRIÆ.—In Saratoga, the direction of drift striæ is N. N. E. They are well preserved on the calciferous sandrock. Location: site of United States Hotel.

NOTE A. CLIFFS.—A later examination of the cliff near the company's dam (east side) calls for a limitation of statements made on pp. 135 and 137. Near the dam is a portion of some fifty rods that is as rugged, nearly as steep, and apparently as inhospitable to trees, as the cove above the falls.

NOTE B. SLIPS.—A half mile below Crescent are some slips that dip N. W. instead of S. E., as do those below the fall. They make some curious combinations that I have sketched (fig. 23). It is doubtful whether *b* continues *a* or *c*, and not unlikely that it has served each in turn. Each of the three shows slides in widely different directions, but the upper surface of the quartz filling of each is marked with striæ, N. 40° W., which is substantially the direction of the plane

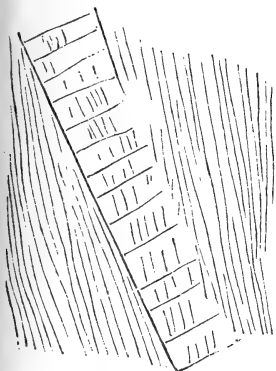
Fig. 23.



of the section that the drawing represents. The direction of *e* was not observed, but in *f* the motion was towards or from the junction. A continuation of *f* may exist somewhere on the lower

side of *e*. This seems the same phenomenon that was noticed before (fig. 10, p. 138), and I see no hypothesis to meet it short of supposing that the shale was so yielding as to be able to accommodate itself to an uneven surface. The same condition seems to be demanded by the combination of faults just alluded to (*a*, *b*, *c*).

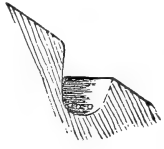
Fig. 24.



A little further down the shore is another fault worthy of note (fig. 24). It is nearly in the direction of the stratification, and on one side is a zone, two and one-half feet wide, of parallel joints normal to the fault.

NOTE C.—For a half mile above the company's dam, on the east side, are numerous marshes that probably cover pot-holes.

## LIST OF POT-HOLES OF THE BED OF THE MOHAWK, ABOVE COHOES FALLS.

No. on map.	Diam. at top.	Depth.	REMARKS.	No. on map.	Diam. at top.	Depth.	REMARKS.
	ft. in.	ft. in.			ft. in.	ft. in.	
1	0 8	1 4	Gravel; i. e., the probe stopped at gravel, and bottom was not reached.	40	3	10	Gravel.
				41	4x8	21	
				42	3	6	Little gravel.
				43	0 10	7	Little gravel.
2	1 3	3	Gravel.	44	1	6	Little gravel.
3	1 2	7	Gravel.	45	0 10	3	Little gravel.
4	1	1	Empty; i. e., containing nothing but water.	46	0 7	2 6	Little gravel.
				47	6x15	10	7 to 10 holes joined at top.
5	4 6	10	Gravel.	48	1	2	Empty.
6	2 6	13		49	1 9	6	Empty; drained by fault in rock.
7	2 6	15		50	10	9	Little gravel.
8	1 3	6	Empty.	51	0 8	2	Little gravel.
9	2	5	Gravel.	52	2x6	6	Little gravel.
10	1 6	9 6	Little gravel; i. e. so little gravel that the probe was forced thro'.	53	12	6	Little gravel.
				54	0 10	2	Little gravel.
				55	0 6	1 8	Little gravel.
				56	0 4	2	Gravel.
11	1 6	4	Little gravel.	57	....	6	Empty.
12	1 6	5	Little gravel.	58	0 10	1 6	Little gravel.
13	3	4	Gravel.	59	1 6	2	Gravel.
14	3	10	Gravel.	60	1 3	1 6	Gravel.
15	8	10	Gravel.	61	1 3	2	Little gravel.
16	0 9	1 6	Empty.	62	1 8	2	Little gravel.
17	0 9	2	Empty; joined at top with 16.	63	1 6	2	1 large boulder.
18	1 6	1 6	Empty.	64	3 6	5	3 separate holes.
19	1	3	Little gravel.	65	1	2	About 65 and 66 are many shallow
20	0 6	1 9	Little gravel.	66	3	4	holes nearly filled with gravel.
21	1	2 6	Empty.				
22	4	14		67	10	4	Gravel.
23	0 10	2 6	Empty.	68	....	....	Shallow holes.
24	4	4	Gravel, irregular.	69	4	3	Gravel.
25	3	8	Gravel.	70	4x7	4	Little gravel.
26	2	17 6		71	0 10	2	Little gravel.
27	3 6	11		72	5x15	5	Little gravel.
28	1 6	2 6	Gravel.	73	....	....	Shallow holes.
29	5	9 6	Little gravel.	74	1 2	2 6	Surrounded by many shallow holes.
30	4x7	4	Large fragments of bed rock.	75	5x8	5	Gravel.
31	2	8	Gravel.	76	2x3	1	Gravel.
32	2	4	Gravel.	77	4x6	5	Gravel.
33	1	6	Gravel.	78	2x4	5	Empty.
34	2	8	Gravel.	79	0 10	2 6	Little gravel.
35	2	5	Gravel.		0 9	2 6	Empty; near 79.
36	3	9	Gravel.		0 9	2	Empty; near 79.
37	0 10	2 6	Gravel.	80	7	2	Little gravel.
38	2 6	14		81	....	....	6 holes, filled with gravel.
39	3x9	8	Section:	82	1 6	3	Little gravel.
		or 20			3	....	Several filled holes near 82.
				83	1	4	Little gravel.
				84	2	....	6 holes filled with gravel.
				85	{ 2 4 }	{ 6 5 }	Little gravel; 2 holes connected.

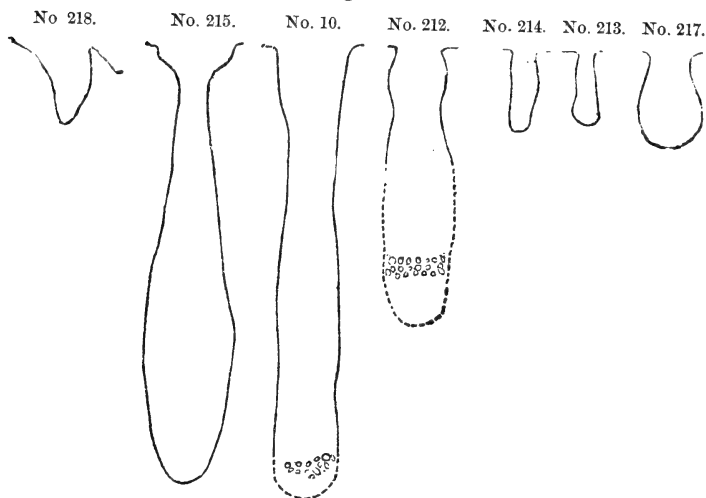


No. on map.	Diam. at top.	Depth.	REMARKS.	No. on map.	Diam. at top.	Depth.	REMARKS.
	ft. in.	ft. in.			ft. in.	ft. in.	
86	1 6	2 6	Little gravel.	144	6x10	5	Gravel.
87	0 10	2 6	Little gravel.	145	....	....	Series of large connected holes.
88	4x6	4	2 holes; gravel.	146	....	....	
89	{ 3 4	{ 4 3	Gravel; 2 holes.	147	0 5	1 6	
90	4x8	6		148	2	2 6	Gravel.
			Little gravel.	149	0 10	2	Gravel.
226	....	....	84, 85, 88 and 89, surround a large hole half filled with gravel.	150	1	2 6	Gravel.
91	8	9	Gravel.	151	4	4	Little gravel.
92	4x8	8	Gravel.	152	9	6	Gravel.
93	3	4	Empty.	153	6	6	Little gravel.
			92 and 93 are surrounded by holes nearly full of gravel.	154	....	1 6	20 shallow holes.
94	1 6	5	Little gravel.	155	2	3	Little gravel.
95	3	5	Little gravel.	156	....	4	Gravel.
96	2	8	Little gravel.	157	2 6	6	Little gravel.
97	3	11		158	3	6	Gravel.
98	2	15	Oblique.	160	5	6	Little gravel.
99	3	9	Empty.	161	0 6	1 6	Little gravel.
100	4x8	6	Gravel.	162	0 10	2	Little gravel.
101	1 6	6	Little gravel.	163	3	3	Little gravel.
102	1	3	Empty.	164	6	10	Little gravel.
103	0 10	0 8	Gravel.	165	1	2 6	Little gravel.
104	12	9	Gravel.	166	1	2	Empty.
105	3	3	Gravel.	167	3x6	7	Gravel.
106	3	3	Gravel.	168	3	2 6	
107	1	2	Little gravel.	169	4x12	7	Empty.
108	5	14	Empty.	170	3	5	Empty.
109	2	4	Little gravel.	171	0 10	3 6	Empty.
110	5	6	Gravel.	172	0 10	3 6	
111	6	6	Gravel.	173	6	14	Empty; partly drained.
112	7	5	Little gravel.	174	3	6	Empty.
113	4	4	Gravel.	175	3x1	4	Little gravel.
114	4	....	Gravel.	176	5	8	Gravel.
115	6	....	Gravel.	177	0 9	2	Empty.
116	9	....	Gravel.	178	6	6	Gravel.
117	2	....	20 shallow holes.	179	10	12	
118	11	6	Gravel.	180	3	23	
119	3	7	Empty.	181	1 2	3	Empty.
120	3	6	Gravel.	182	4 6	2	Gravel.
121	....	7	Gravel.	183	0 10	2 6	Gravel.
122	3	12		184	2	2	Gravel.
123	0 6	2 6	Little gravel.	185	1 6	2	Gravel.
124	4x5	12	Gravel.	186	1	2	Gravel.
125	3x4	10		187	1 6	2	Little gravel.
126	3	5	Gravel.	188	1	3	Empty.
127	8x15	9	Gravel.	189	0 10	1	Little gravel.
128	0 10	2 6	Gravel.		0 10	0 10	10 holes near 189 and 190.
129	2 6	3	Little gravel.	190	1	3	2 holes; little gravel.
130	0 6	2 6		191	2	3	Gravel.
131	0 6	1 6		192	3	4	Gravel.
132	2	4	Gravel.	193	....	....	Shallow holes.
133	8	10	Gravel.	194	2	6	Gravel.
134	1 6	6	Empty.	195	4	11	Empty.
135	....	1	Gravel.	196	5	8	Gravel.
136	0 6	2	Little gravel.	197	1	1	5 shallow holes.
137	2	2	Gravel.	198	1 2	3	
138	1	....	Gravel.	199	0 3	1	
139	1 6	2	Gravel.	200	....	....	
140	0 9	4	Gravel.	201	....	....	
141	0 3	1 6	Gravel.	202	2	3	Gravel; 2 holes.
142	0 9	3	Empty.	203	3	3	Gravel.
143	4	8	Gravel.	204	2	4	Empty.
				205	2	2	Gravel.
				206	2	5	Empty; 6 shallow holes.

No. on map.	Diam. at top.	Depth.	REMARKS.	No. on map.	Diam. at top.	Depth.	REMARKS.
	ft. in.	ft. in.			ft. in.	ft. in.	
207	0 10	2	Gravel; 2 holes.	217	1	2	Empty.
208	....	....	20 shallow holes.	218	1	1 8	Empty.
209	....	....	Shallow holes.	219	3	7	Gravel.
210	4	10	Gravel.	220	2	2	
211	1	2	Gravel.	221	4	6	Empty.
212	1	6	Gravel.	222	3	8	Little gravel.
213	0 4	1 6	Empty.	223	3 6	8	Gravel.
214	0 4	1 8	Empty.	224	1	3	Empty.
215	1 6	9	Empty.	225	1	3	Empty.
216	4	10	Gravel.	226	....	....	See 90, 91.

## FORMS AND PROPORTIONS OF POT-HOLES.

Fig. 25.



The above figure (25) represents some of the more remarkable forms existing among the pot-holes, recorded in the preceding list; they are drawn on a scale of one-fourth of an inch to the foot. Corresponding numbers will be found on a map accompanying this report, a reference to which will enable the reader to determine their position and relation to other pot-holes.

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TO THE

# ANNUAL REPORTS, I—XX,

ON THE

# STATE CABINET OF NATURAL HISTORY,

Exclusive of the Geological and Palæontological Papers.

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\*An error in the report: Mr. Almeron Phillips was the donor.

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\*This fossil (*Colpoceras virgatum* Hall) was returned to the depositor, Nov. 24th, 1865, and a receipt for its delivery taken, but inadvertently, no record of the return has been made in any subsequent report.

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## PLATES AND EXPLANATIONS.

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Through an oversight, the Plates illustrating the paper "On the Cohoes Mastodon," bear the same numbers (I—VI) with those which illustrate a preceding paper on "The Stone and Bone Implements of the Arickarees."

#### EXPLANATION OF PLATE I.

- Fig. 1. Stone Maul.
- “ 2. Stone Maul: in handle, encased in raw hide.
- “ 2 A. Same: showing hammer face.
- “ 3. Stone Maul: much worn.

Fig. 2.A.



Fig 2.



Fig 3.

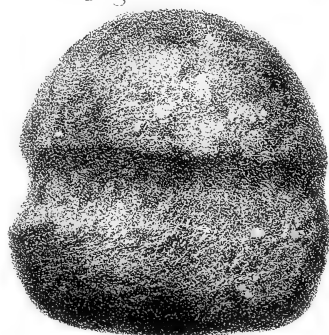
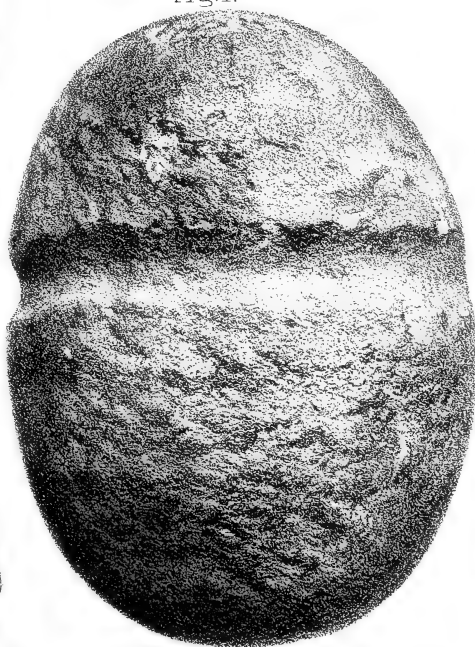


Fig.1.









#### EXPLANATION OF PLATE II.

- Fig. 4. Stone Hammer: in handle, and encased in buffalo raw hide  
“ 4 A. Same: showing hammer face.  
“ 5. Stone Hammer.  
“ 1 A. Stone Maul: showing interruption of groove.

Fig. 4. A



Fig. 4



Fig. 5.

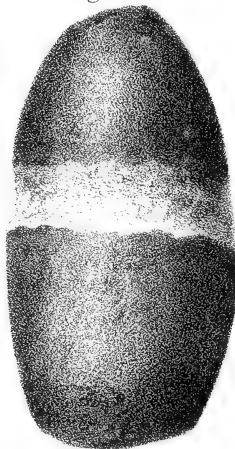
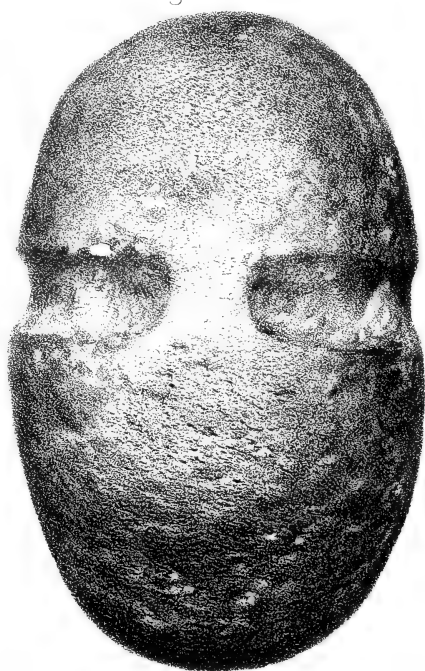
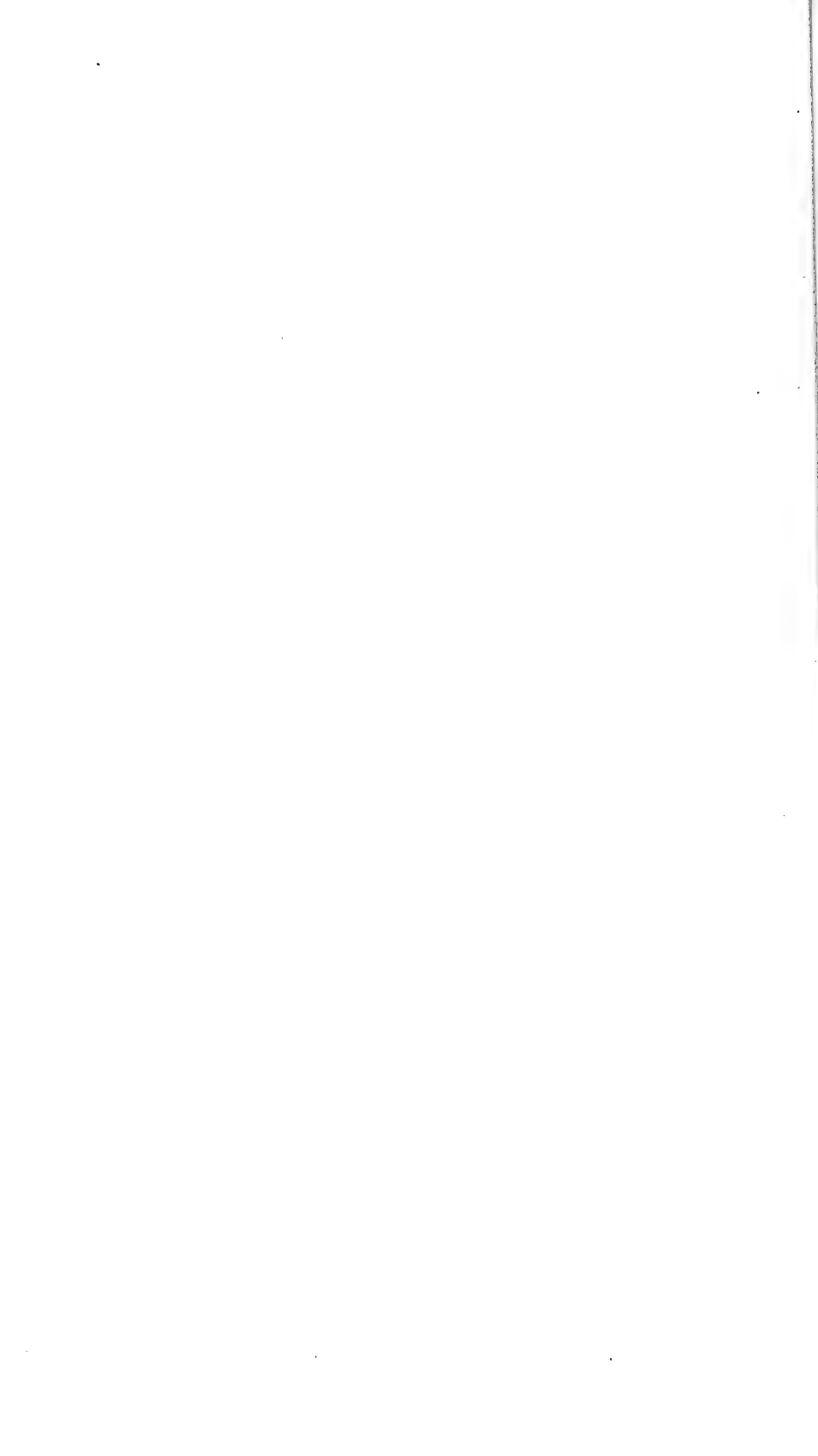


Fig. 1. A.







### EXPLANATION OF PLATE III.

- Fig. 6. Stone Hammer in Handle.  
“ 7. Stone Hammer : much worn.  
“ 8. Stone Hammer.  
“ 9. Stone Hammer : much worn.  
“ 10. Stone Crusher or Pestle.  
“ 11. Stone Hammer.

Fig. 7.



Fig. 6.



Fig. 8.



Fig. 10.

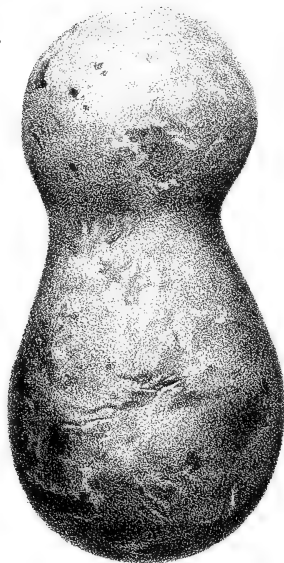
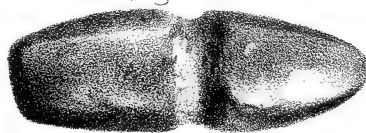


Fig. 9.

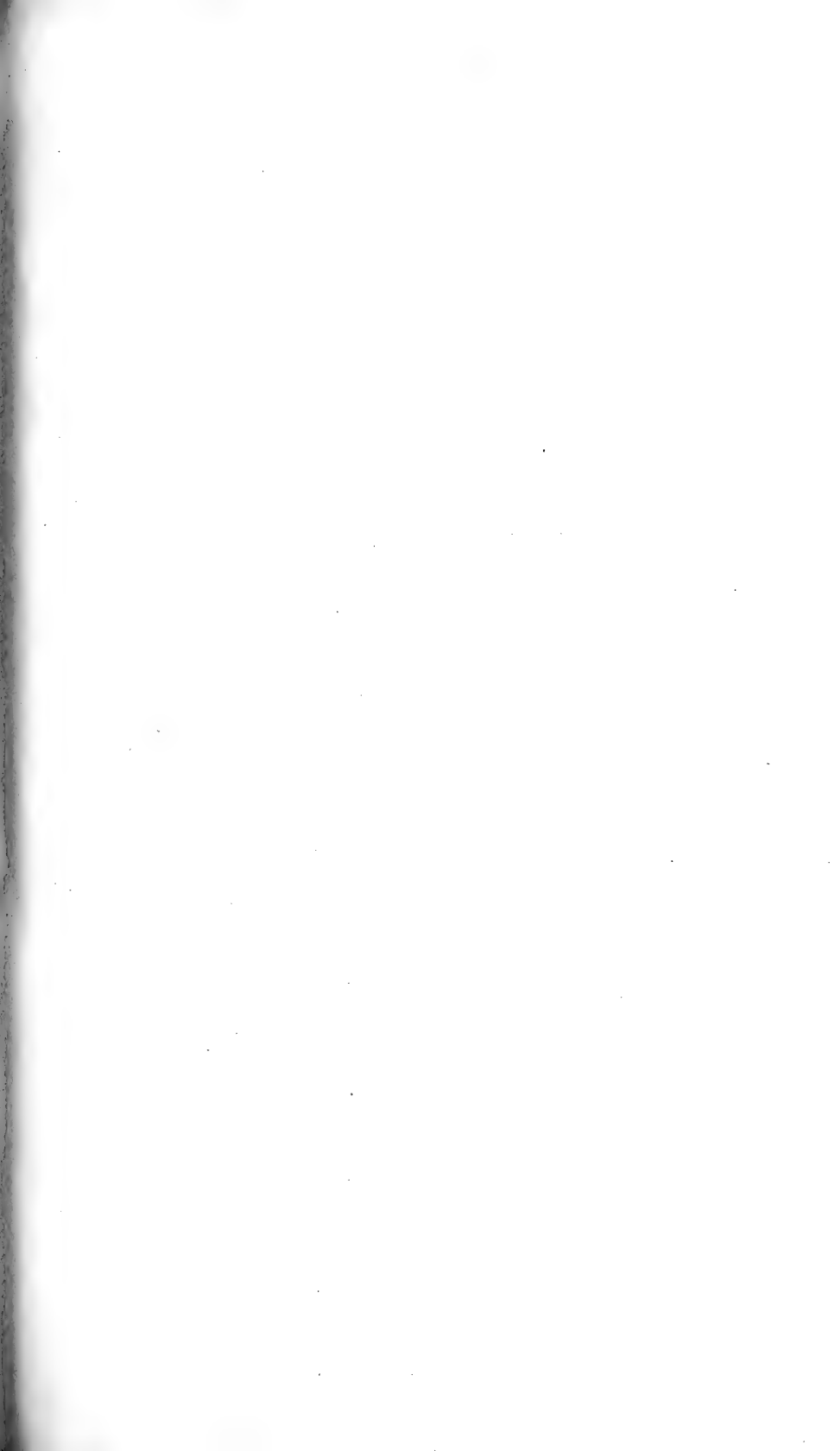


Fig. 11.









#### EXPLANATION OF PLATE IV.

Fig. 12. Skin-dresser of Elk-horn.

“ 13. Bone Moccasin-smoother.

“ 14. Buffalo-horn Spoon.

Fig. 12.



Fig. 13.

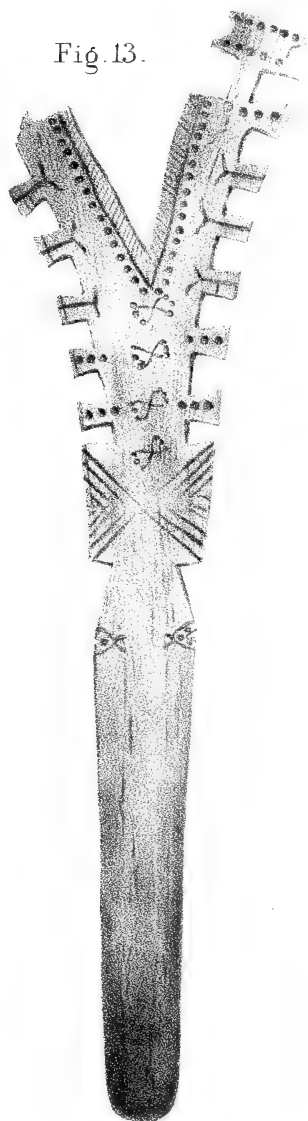


Fig. 14.







### EXPLANATION OF PLATE V.

Fig. 15. Iron Tomahawk.

“ 16. Corn Mortar.

“ 17. Section of Mortar showing cavity.

“ 18. Corn Pounder. (The ends are reversed.)

“ 19. Ladder.

“ 20. Willow Screen.

“ 6A. Stone Hammer : showing face.

Fig. 6. A.



Fig. 15.

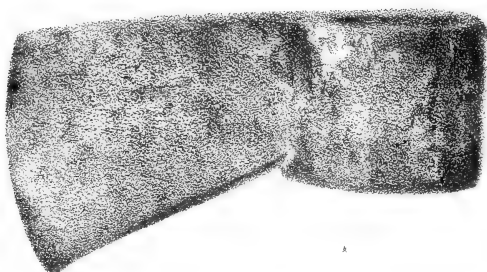


Fig. 16.

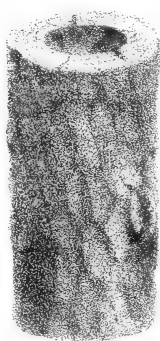


Fig. 17.



Fig. 19.

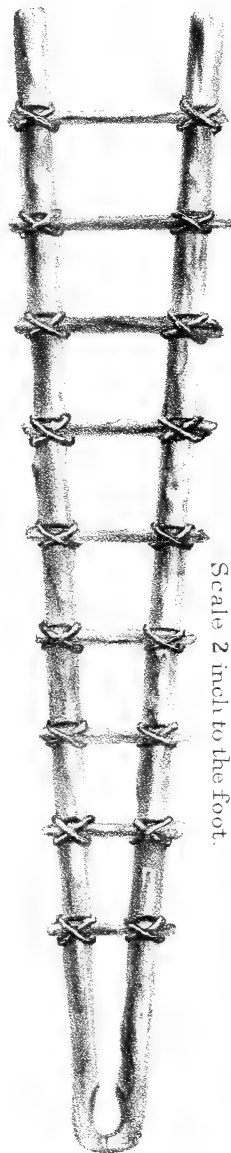
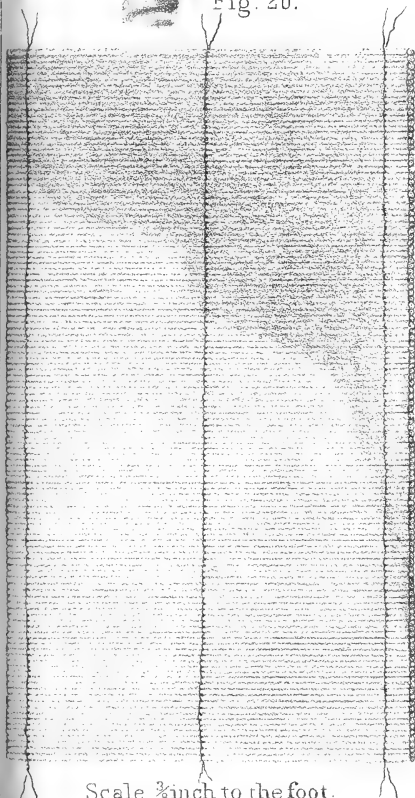


Fig. 20.



Scale  $\frac{1}{2}$  inch to the foot.

Fig. 18.

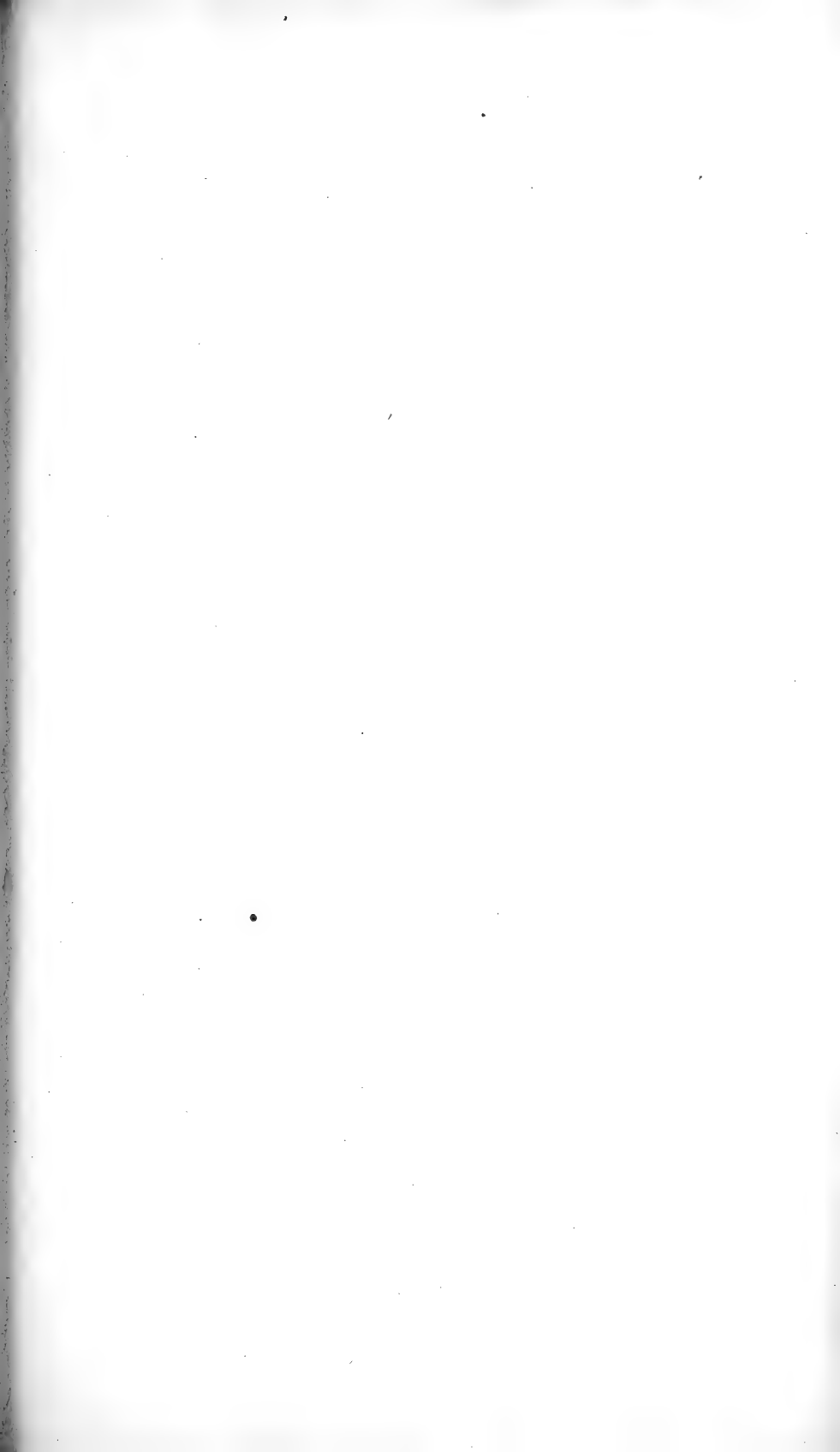
Scale 1 inch to the foot.



Scale 2 inch to the foot.







#### EXPLANATION OF PLATE VI.

Fig. 21. Ground plan of old Mandan Village.

“ 22. Ground plan of Mandan House.

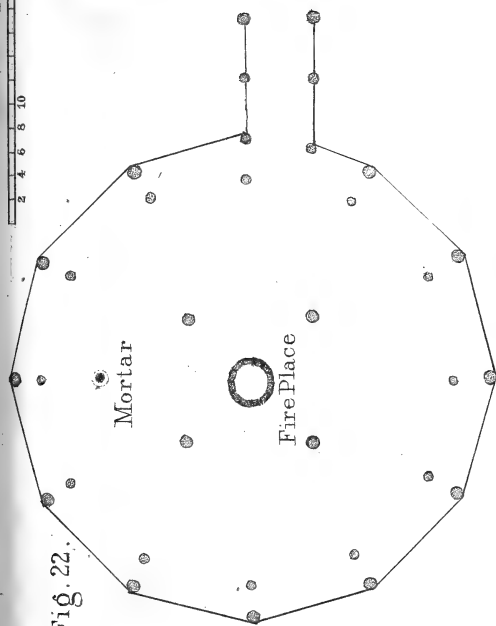
“ 23. Cross section of Mandan House.

“ 24. Front elevation of Mandan House.

“ 25. Drying-scaffold.

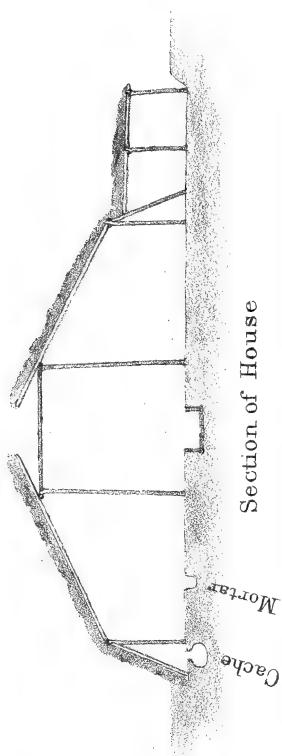
Feet  
2 4 6 8 10 20 30 40

Fig. 22.



Ground plan of House

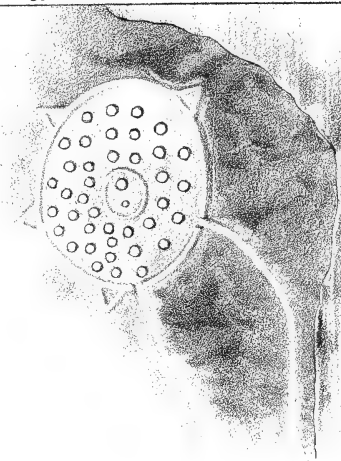
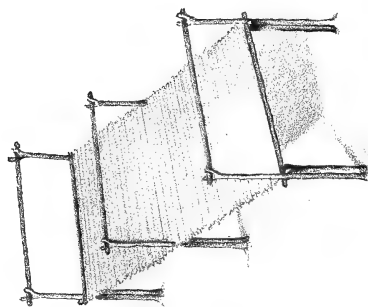
Fig. 23.



Section of House

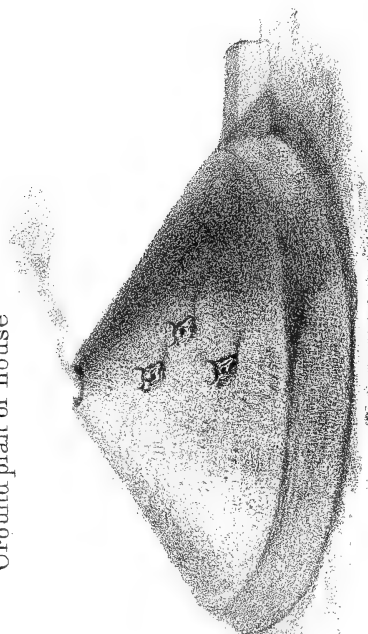
Fig. 21.  
Mandan Village Plot.

Fig. 25.  
Scaffold



100 200 300 400 500  
Paces

Fig. 24.



Mandan House



# EXPLANATION OF PLATES

## RELATING TO THE COHOES MASTODON.

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### PLATE I.

A map (on a scale of about two miles to the inch), showing the junction of the Mohawk and Hudson rivers, with the position and relation of the principal places referred to in the article on the Cohoes mastodon.

### PLATE II.

No. 1. A section across the Mohawk valley, one mile below Crescent, showing the outline of the valley and the relations of the drift or gravel beds, the estuary clay and the alluvium of the valley.

The lower part of the drift, in this and the other sections, is of glacial origin, resting upon the striated and smoothed surfaces of the rock. The upper portion of the drift is water-worn, and more or less sorted and stratified by the action of water.

No. 2. Section across the valley, opposite the Harmony mills, showing the deep, nearly vertically walled channel below the falls; with a narrow, deeper channel in the center, which is the only part occupied by water during the dry season.

Two sections of ancient pot-holes are shown in the slate rock on the east side of the river.

No. 3. Longitudinal section of the river bed along the main channel from opposite the Harmony mills to the basin of deep water above the falls. The basin of deep water below the falls communicates with the narrow, deep channel in section No. 2, in the middle of the river bed; and also on Plate iii along the center of the river channel.

### PLATE III.

A map reduced from a large working map (4 x 9 feet), now in the State Museum, upon which all the observations of the survey were recorded.

For the explanation of the figures in the river channel, and the different representations of the pot-holes, see explanations above the title.

The ancient pot-holes marked upon the eastern margin of the river opposite the falls, are cavities in the slate filled in their upper part with water and peaty matter; they are entirely similar in their character to those in which the remains of Mastodon were found.

On the lower side of the map at Harmony mill No. 3, is shown the outline of the pot-holes in which the mastodon remains were found. Other smaller pot-holes are represented, and one larger one to the east of the mill.

#### PLATE IV.

The diagram at the left hand upper part of the sheet, represents the position of the large pot-hole in which the mastodon remains were found, and its relation to numerous other smaller pot-holes; the river bank being represented on the right hand margin of the sheet. Several of the smaller pot-holes occur between the mill and the river bank, and others on the east side and beneath the tower. Those which were particularly examined, including the two larger ones, are marked 1 to 26 inclusive. The large one marked *Peat bog*, between the mill and river bank, was sufficiently proved by excavation to be a large pot-hole, having a diameter of sixty-three feet. In digging a drain from the large pot-hole beneath the mill to the river bank, this bog was cut to the depth of ten feet, and was afterwards sounded by steel rods to a farther depth of sixteen feet, without reaching any hard substance. Between this cavity and the one beneath the mill, there had formerly been a communication by a shallow depression in the rock.

The line indicated by the letters A L F and H, marks the limit of the principal pot-hole at about the present level of the mill floor. The dotted line within this, marked by the letter J, indicates the limit at the bottom. The space between J and H is occupied by an irregular slope descending to J, and this depression at a higher level, extended still farther to the eastward.

The outer dotted line represents approximately the original limits of a swamp with a central pond, which originally covered the openings of all the pot-holes below.

The pot-hole beneath the mill, marked 1, in which the mastodon remains were principally found, is of an oval form, its greatest diameter being in a line nearly east by north and west by south. To the northwestward it communicates through a deep gorge (between the points B and G) with a large, deep pot-hole, No. 2. The points of rock B and G are arched over, from excavation below, so as to come within a few feet of each other, leaving the opening much wider below.

The form of the opening and the measurements were taken on the level of the mill floor as it then existed.\* The points marked A B C D, are those upon which rest the arches supporting the walls of the building above these cavities.

Distance from A to B, 33 feet.

“ “ B to C, 29 feet.

“ “ A to C, 62 feet.

“ “ L to H, 73 feet.

“ “ F to Fi, 38 feet.

“ “ i to k, 17½ feet.

The rock marked Table is a large mass of slate, 12 × 18 to 20 feet across the

---

\* The surface of the rock was afterwards lowered by excavation about eighteen inches.

surface, which is eight to ten feet below the level of the floor of the building. This rock, on its upper face, presents the limits marked by the continuous line, sloping a little towards F, where it is two feet lower than on the opposite side. The northerly face of this mass is nearly vertical, the top being slightly overhanging; the easterly face is also essentially vertical. On the southerly and south-westerly faces the surfaces are sloping downward to the limit indicated by the dotted line.

Near the base of this mass there is a regular even line of fracture, or natural jointing, along which the mass has apparently slipped for a distance of about one foot to the southeastward, since the formation of the pot-hole, leaving the base projecting at *b*, as shown in the accompanying wood cut, fig. 1, which represents a transverse section of the principal cavity along the face of the table rock from F to Fi.

The point marked G is at about the same level as the central table rock, the arc indicating that it has at one time formed a part of the bottom of a pot-hole, gradually curving upwards to within two and a half feet of the floor level, with the margin perpendicular. At E there is a narrow passage, measuring twelve feet from *g* to *h*, which is filled up by a large mass of the slate rock. This has apparently been pushed forward from above, or fallen into the gorge at a former period. Beyond the slaty mass the channel is filled with loose earth and other foreign materials. This channel is probably the course by which the water entered the larger excavations to the southward.

The larger cavity is deepest at F, though the entire depth is unknown. Within the outer dotted line there are several smaller pot-holes, marked 6, 7 and 8. No. 6 is nine feet ten inches in diameter, the depth not ascertained. No. 7 is ten by twelve and a half feet in diameter. No. 8 represents two small pot-holes, worn into each other at their adjacent margins.

In the tower, 140 feet from the north wall, there are evidences of eight other pot-holes, of various sizes. No. 10 is represented in section (Fig. 2 of diagram), as described by Mr. Houlihan, superintendent of the work.

The points marked by horizontal lines represent the places at which parts of the mastodon skeleton were found, *a* being the point where the lower jaw and one of the phalanges of the left fore foot were found; *b*, the place of the skull, most of the vertebræ and ribs, the pelvis, scapula, leg and foot bones, etc.; *c*, one of the vertebræ; *d*, place of one of the anterior ribs; *e*, place of a rib. At *f*, in pot hole No. 3, the bones of the right fore leg were found at about sixty feet distant from the place of the skull and other bones.

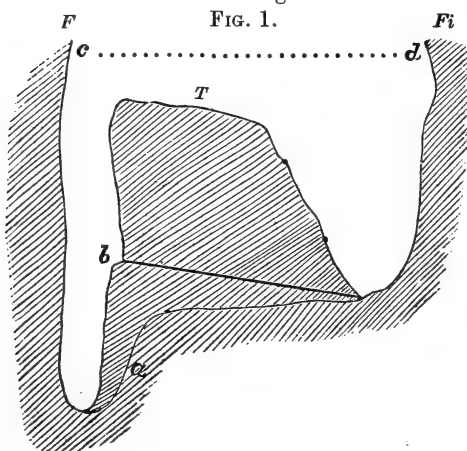
FIG. 2.—Section of pot-hole No. 10, at the angle of the tower.

This pot-hole is narrow above, having a depth of nineteen feet six inches. The diameter at the top is sixteen inches, and in the widest part eight feet. At the first contraction below the centre it has a diameter of two feet, and at the lower one the diameter is but six inches. It was originally filled with water-worn gravel, to the height of the dotted line.

FIG. 3.—A section across the river-bed, from north to south (N. S.). *a* represents the gravel hills underlaid by clay; *b*, the Erie canal; *c* and *d* are raceways, excavated in the slate rock, for carrying water to the mills; *e*, the new Harmony mill; *f*, dwelling-houses on the summit of the river bank; *g*, top of river bank before excavation, which is 106 feet above the level of the river-bed; *g* represents the level of the mill-yard; *h*, level of the water in river-bed at ordinary stage. During the dry season the water is confined to the narrow channel below

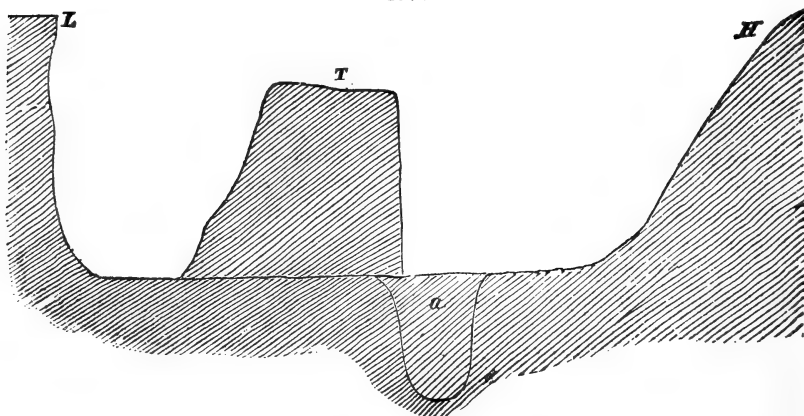
the letter *h*. The height of the bank on the north side, indicated by the letter *g*, is somewhat less than that of the south side.

The accompanying wood cuts represent the transverse and longitudinal sections of the large pot-hole No. 1, showing the position of large mass of slate represented as the Table rock in the diagram.



The line *cd* is in the direction from *F* to *Fi* of the diagram. *a* represents the line of the floor of the pot-hole, upon which the principal parts of the mastodon were found, curving downwards to the deeper part in the direction of *F*. *b* represents the line of slipping of the mass and the projection of the rock below.

FIG. 2.



A longitudinal section of the pot-hole from *L* to *H*, showing the position of the Table rock. *a* represents the deeper part of the pot-hole, towards *F*.

## PLATE V.

A view of the south end of the large pot-hole, from which the principal part of the mastodon bones were taken. The outline is irregular, showing two recesses, which are the margins of two smaller pot-holes, which with other similar ones had been so worn as to communicate, forming one large cavity.

The lower jaw of the mastodon was found at a point (*a*) on the margin of the left hand niche, and near the level of the water, as shown in the plate. (See *a*, diagram, plate 4.) The greater part of the bones were found at a depth about twenty-five feet lower than the water line, as shown in the figure.

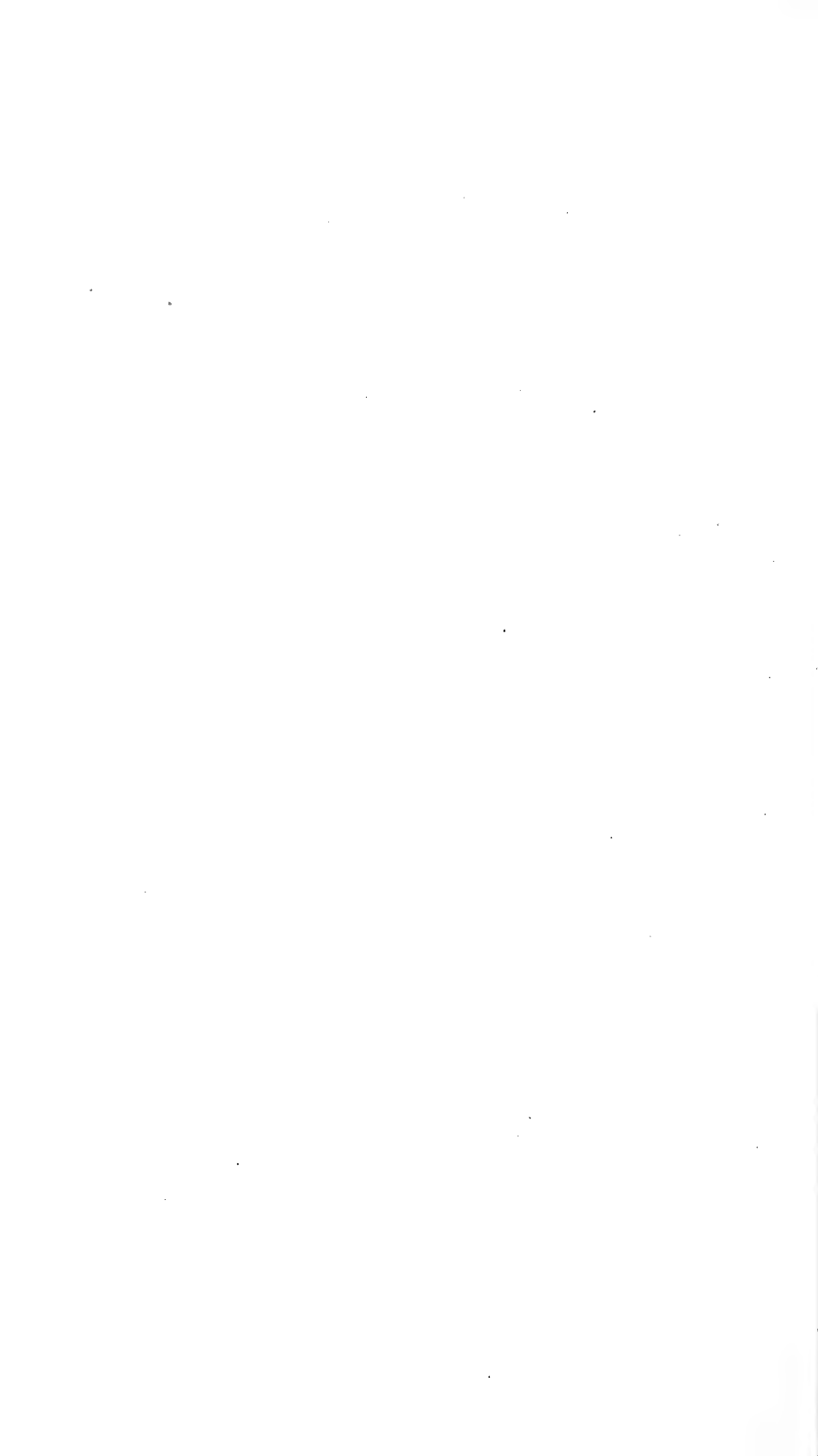


## PLATE VI.

View of the skeleton of the Cohoes Mastodon, as mounted in the State Museum of Natural History. The measurements and description are given in the text.

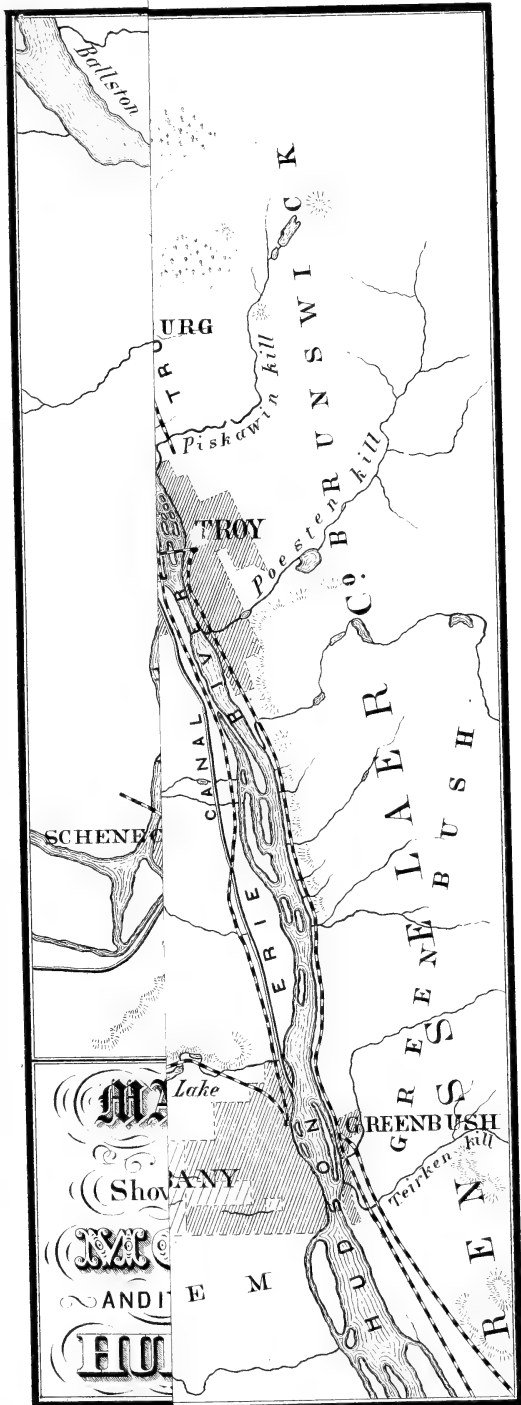
## PLATE VII.

The plate gives a posterior view of the skeleton, and a view of the lower jaw, showing the position of the single tooth in the right ramus, which corresponds to the anterior tooth of the left ramus; the posterior tooth never having been developed.

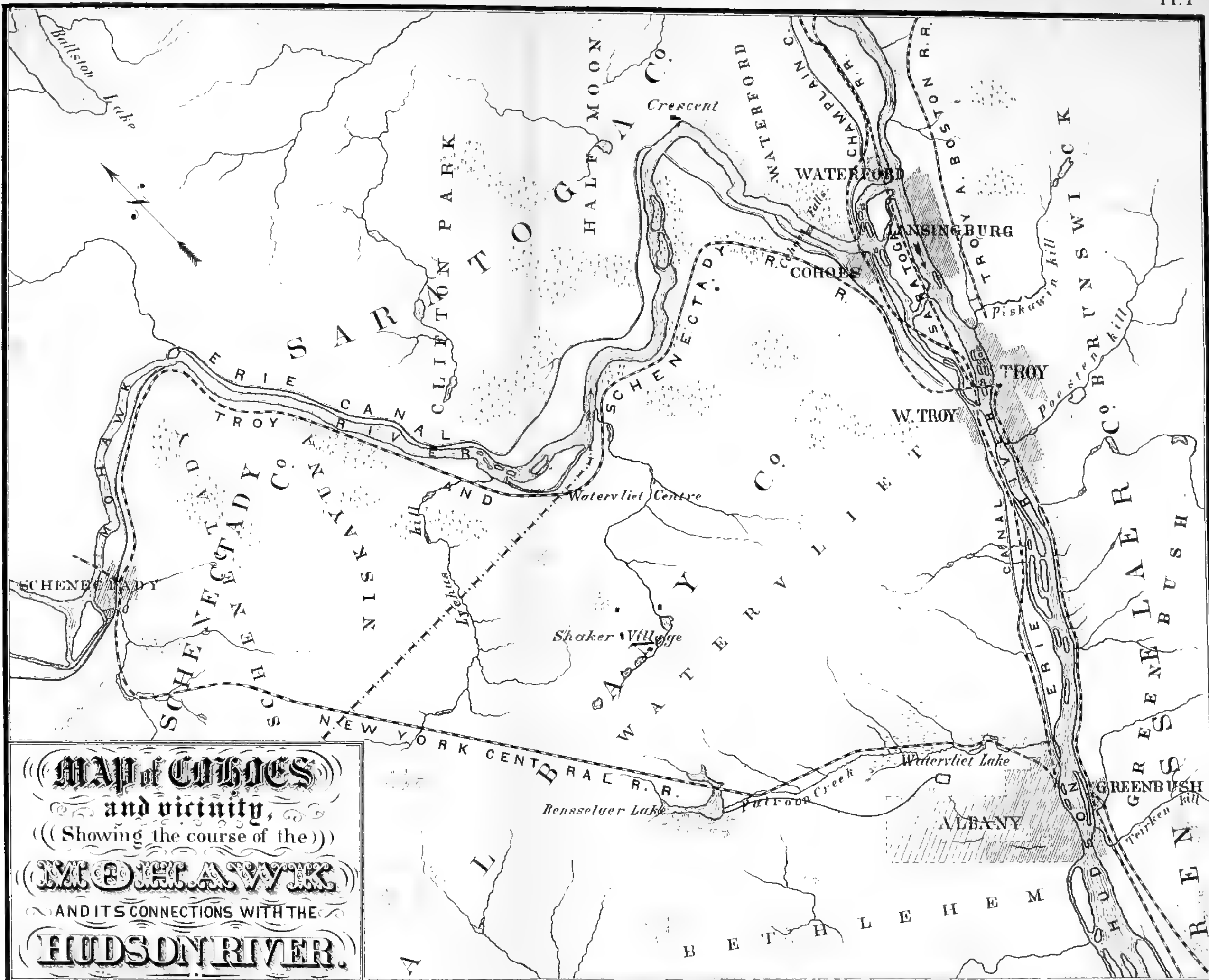






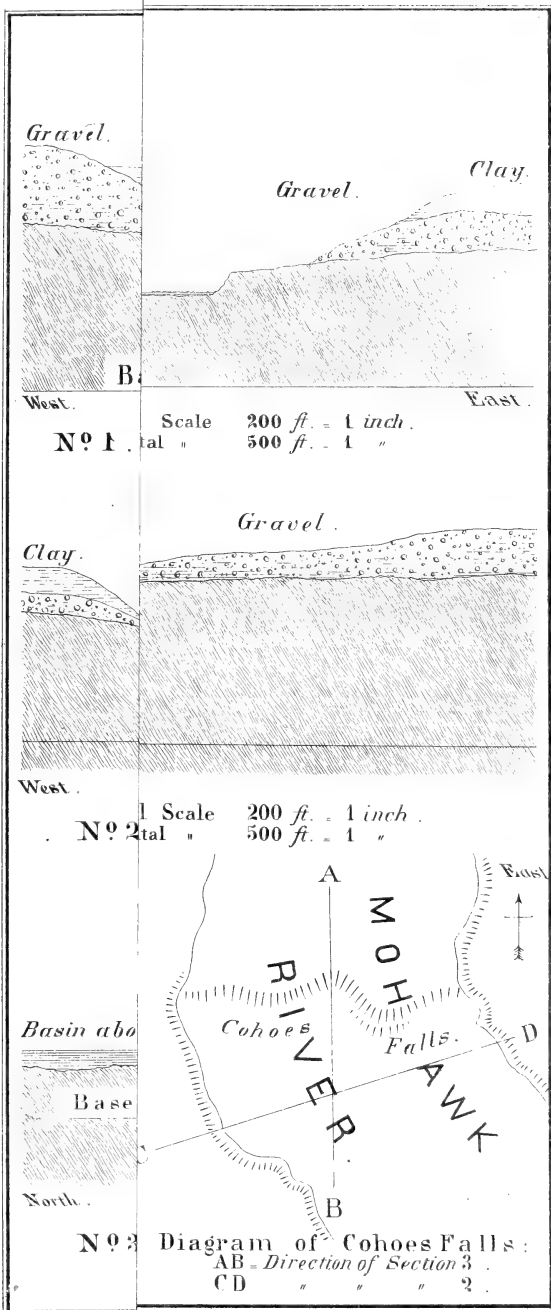




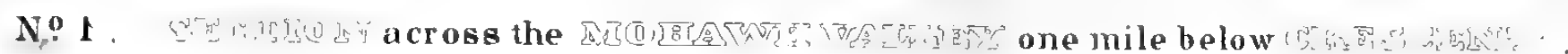








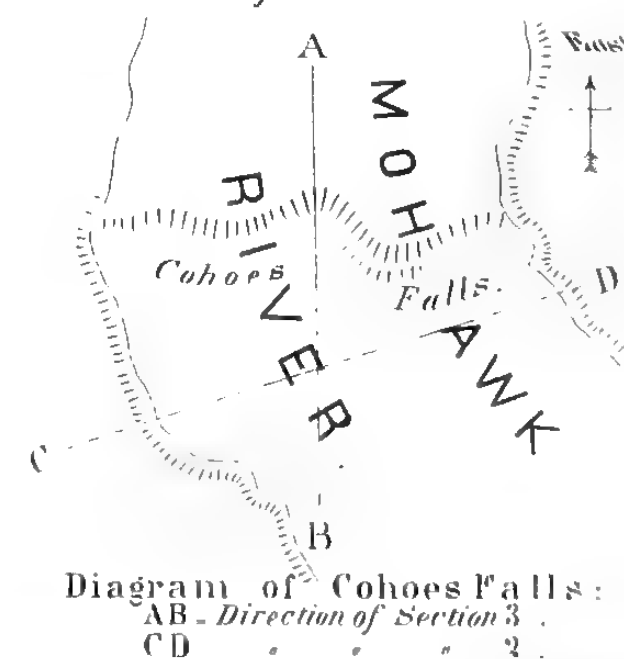




{ Vertical Scale    200 ft. = 1 inch.  
 { Horizontal    "    500 ft. = 1 "



{ Vertical Scale    200 *ft.* = 1 *inch.*  
 { Horizontal        500 *ft.* = 1 "



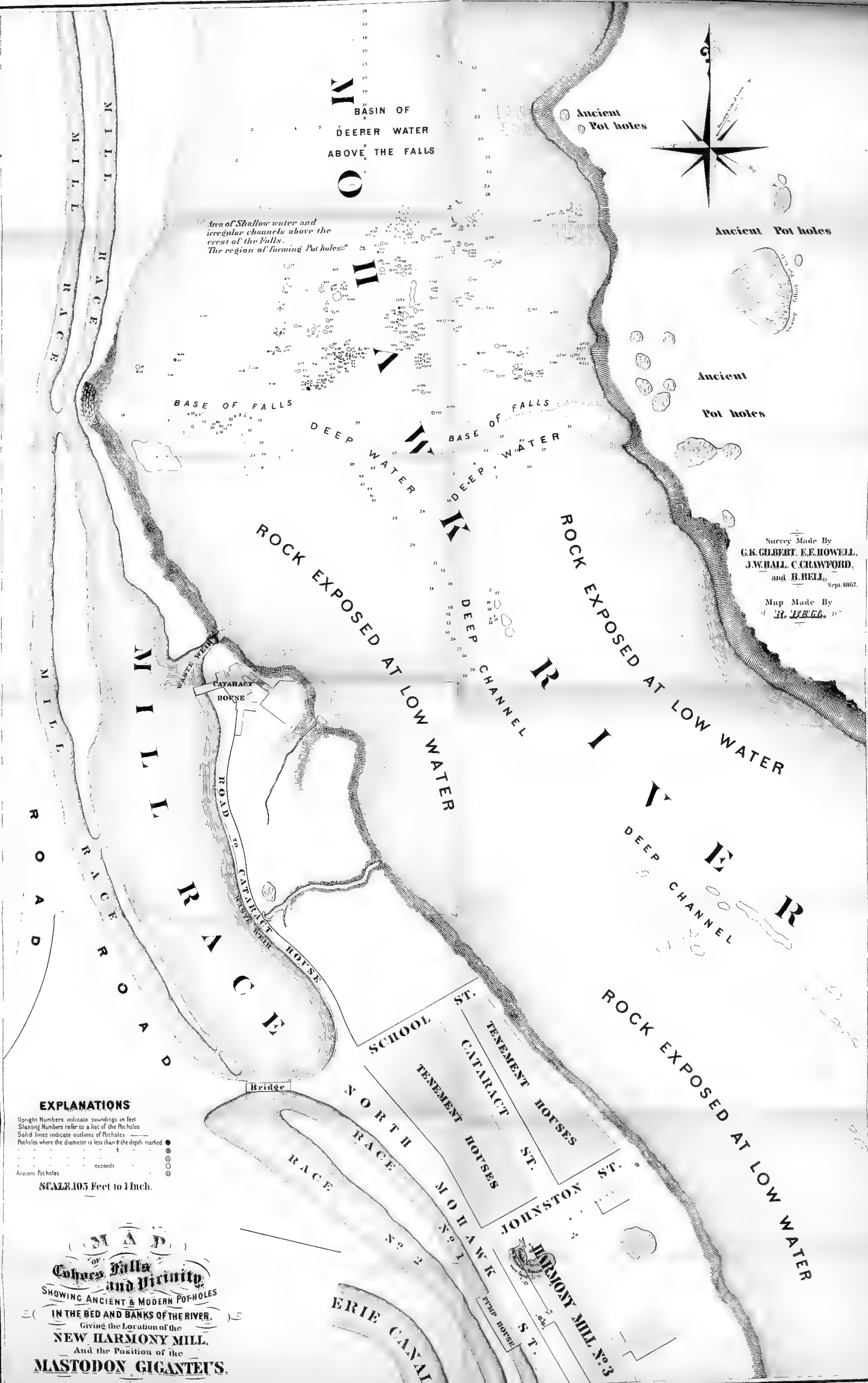




**Showing Ancient & Modern  
In the Bed and Banks of the  
New Harmony  
And the Position of the  
MASTODON GIGA**

Van Benthuysen Printing House, Albany





**EXPLANATIONS**

Upright Numbers indicate soundings in feet  
Slanting Numbers refer to a list of the Pot holes  
Solid lines indicate outlines of Pot holes  
Pot holes where the diameter is less than the depth marked  
● exceeds  
○ Ancient Pot holes

SCALE 105 Feet to 1 Inch.

**MAP**  
**Niagara Falls and vicinity**  
SHOWING ANCIENT & MODERN POT-HOLES  
IN THE BED AND BANKS OF THE RIVER.  
Giving the Location of the  
**NEW HARMONY MILL.**  
And the Position of the  
**MASTODON GIGANTEUS.**

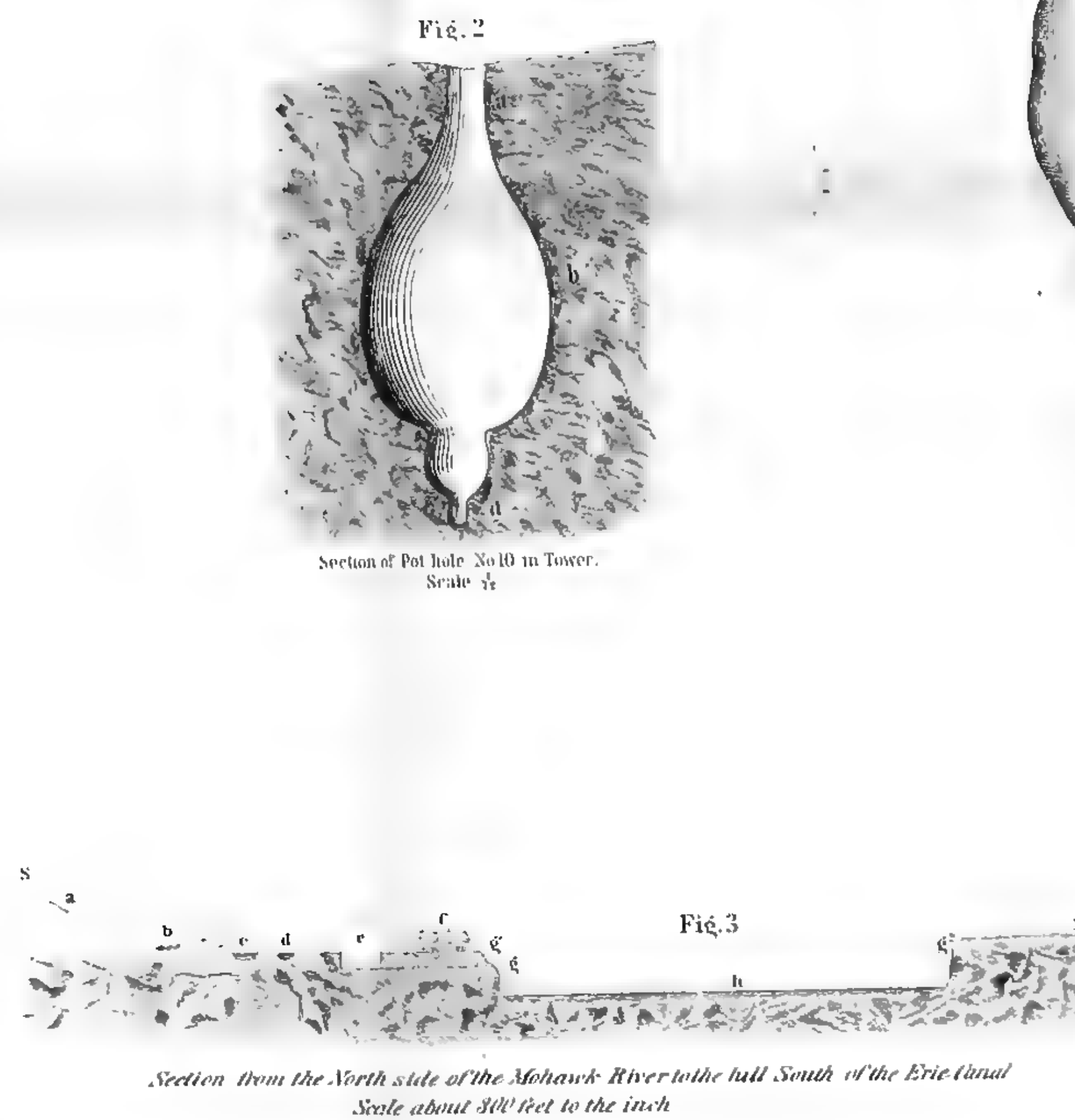
Survey Made By  
**G. K. GILBERT, E. E. HOWELL,**  
**J. W. HALL, C. CRAWFORD,**  
and **H. BELL.**  
Sept. 1867.  
Map Made By  
**H. BELL.**





# PLATE 4





**DIAGRAM**  
OF ANCIENT POT HOLES AT  
HARMONY MILL, COHOES; N.Y.  
SHOWING THE POSITION OF THE BONES  
OF THE  
**MASTODON SKELETON.**

Surveyed and drawn by R.P. WHITFIELD.  
Scale of Map, 12 feet to one inch











HAINES PHOTO - LBANY, N.Y.

CHARLES VAN DENTHUIS & SONS

ROCK EXCAVATION AND OPENING OF THE LARGE POT HOLE  
IN WHICH THE **MASTODON SKELETON** WAS FOUND AT  
COHOES, N. Y., 1866.

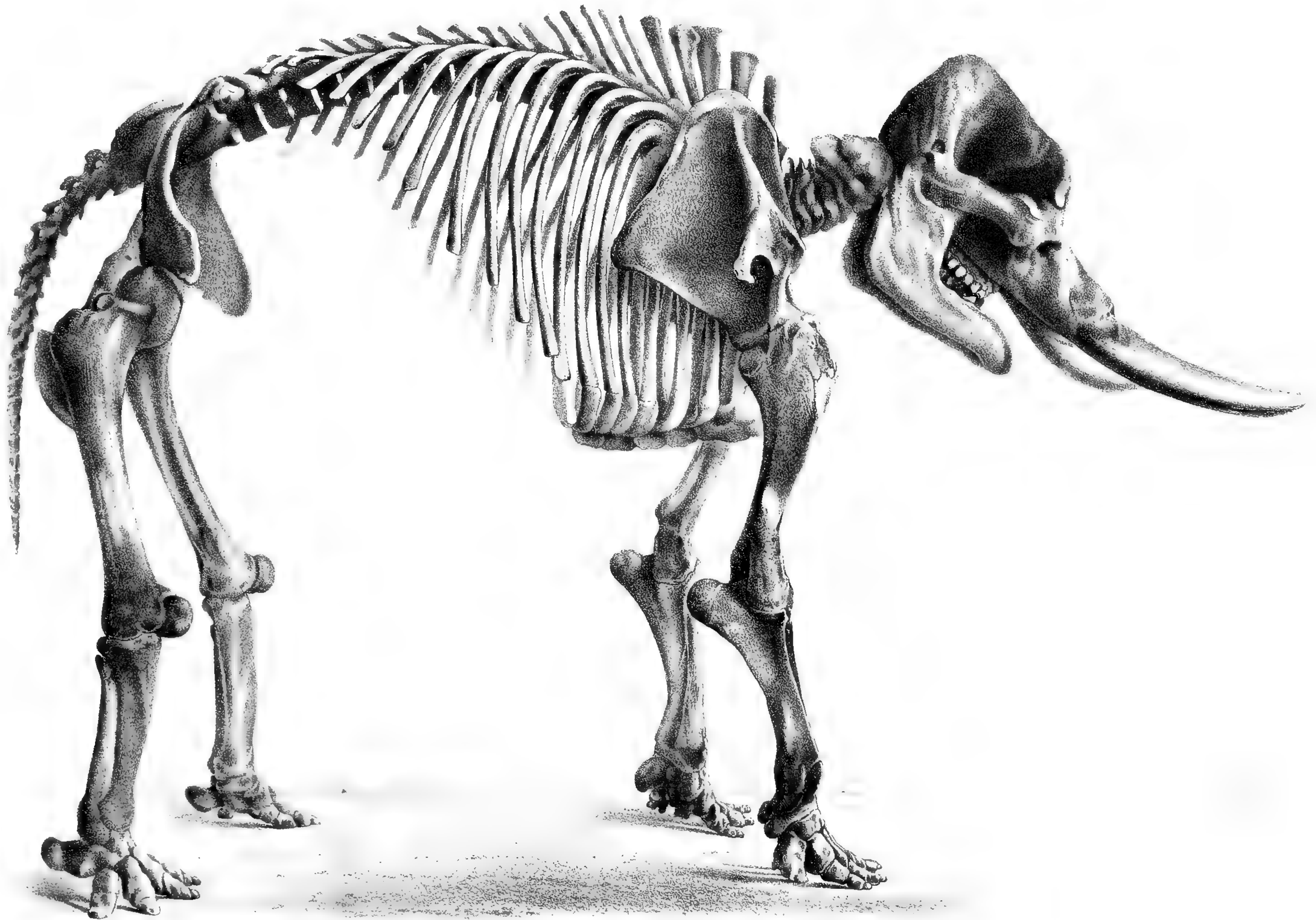






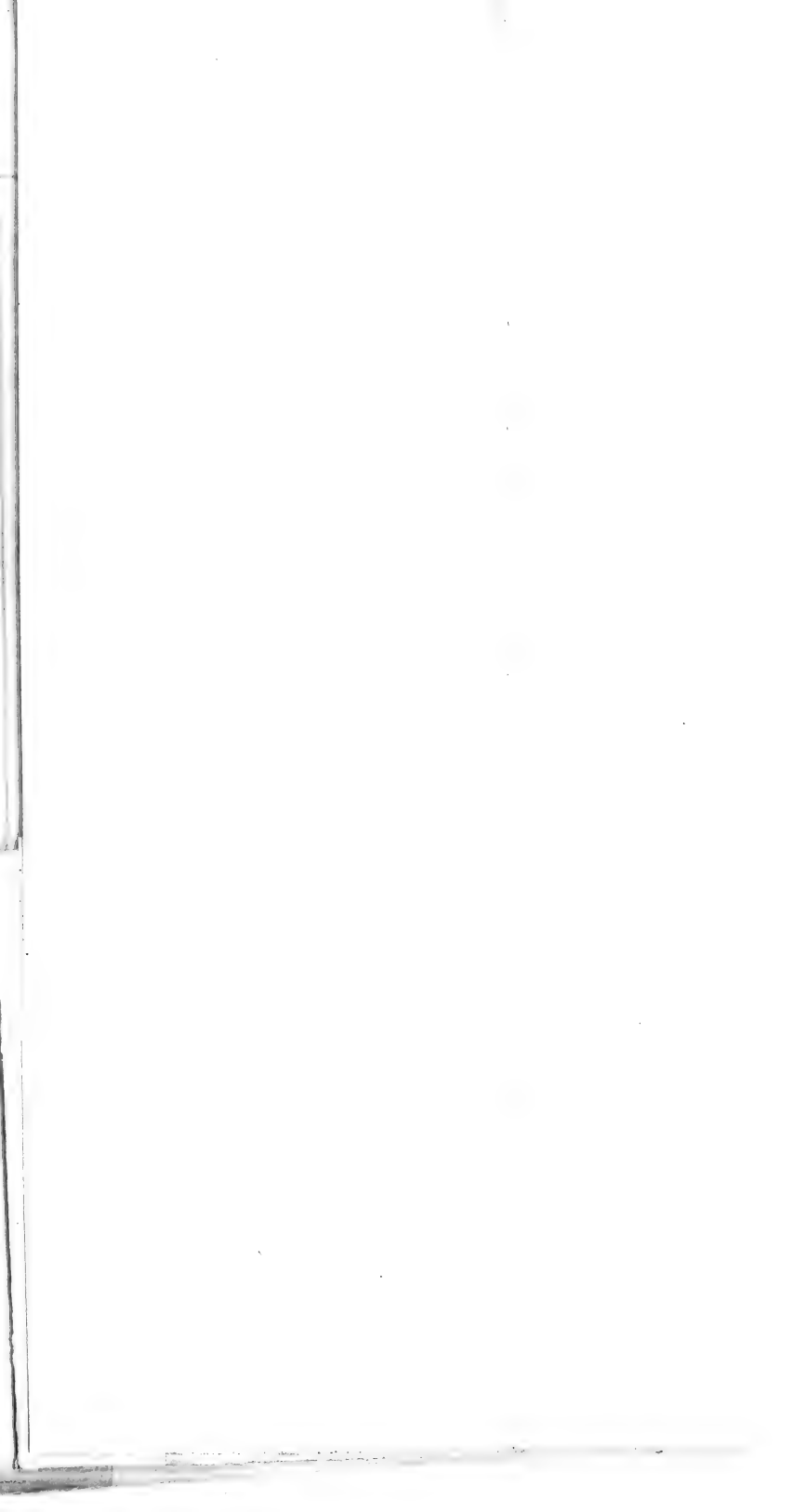




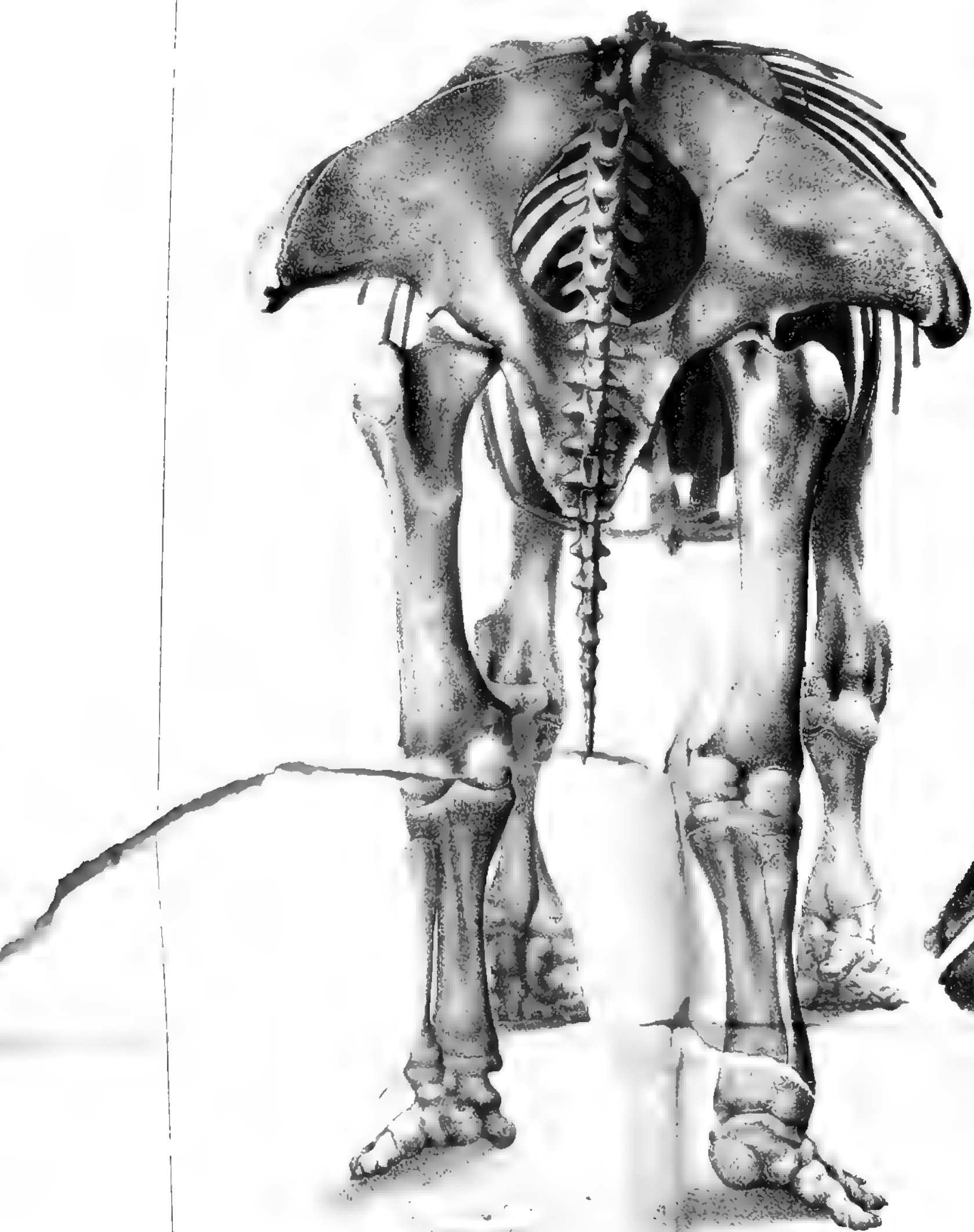


Skeleton discovered at Cohoes 1866.

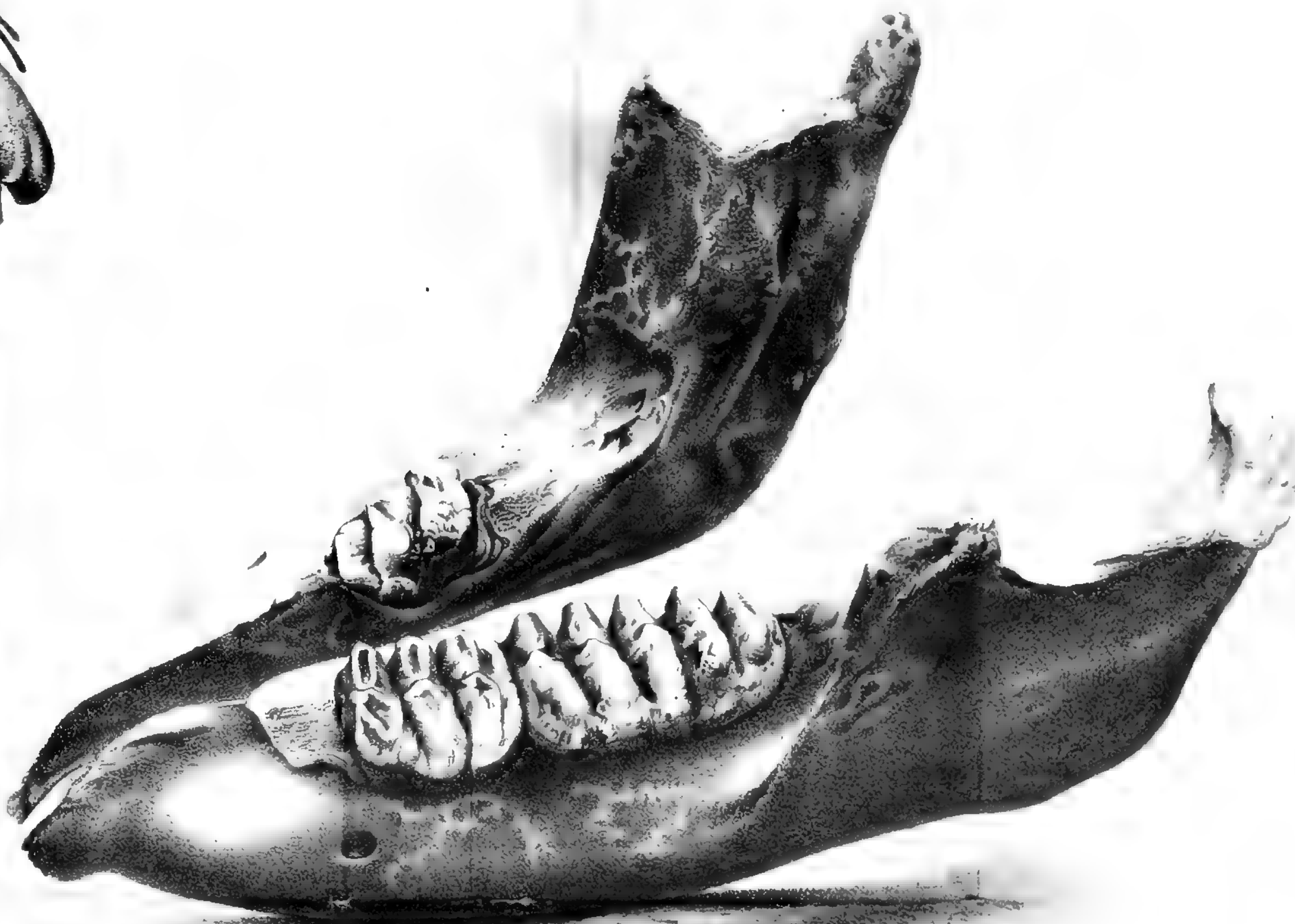




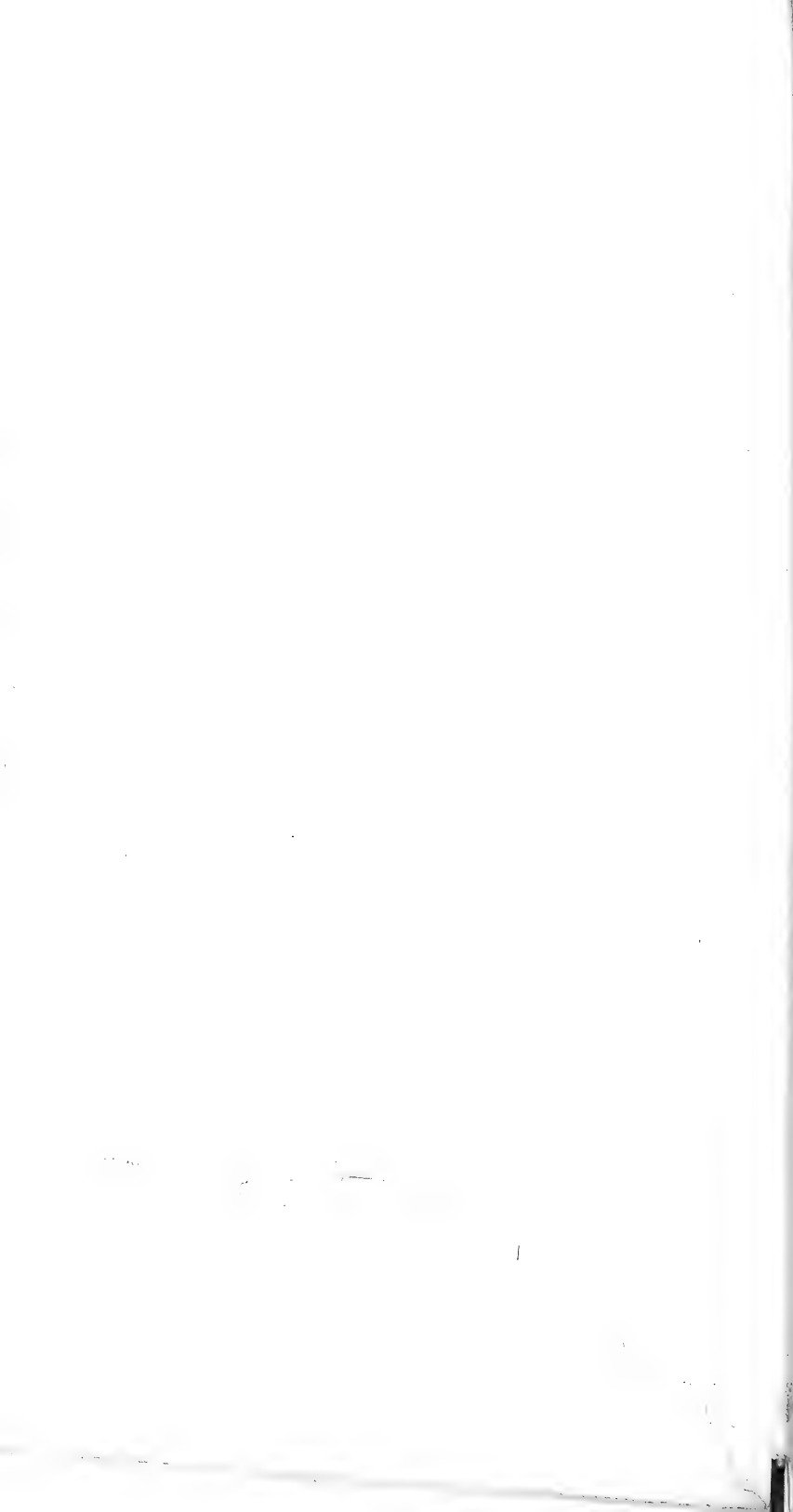




Posterior View



Lower Jaw.

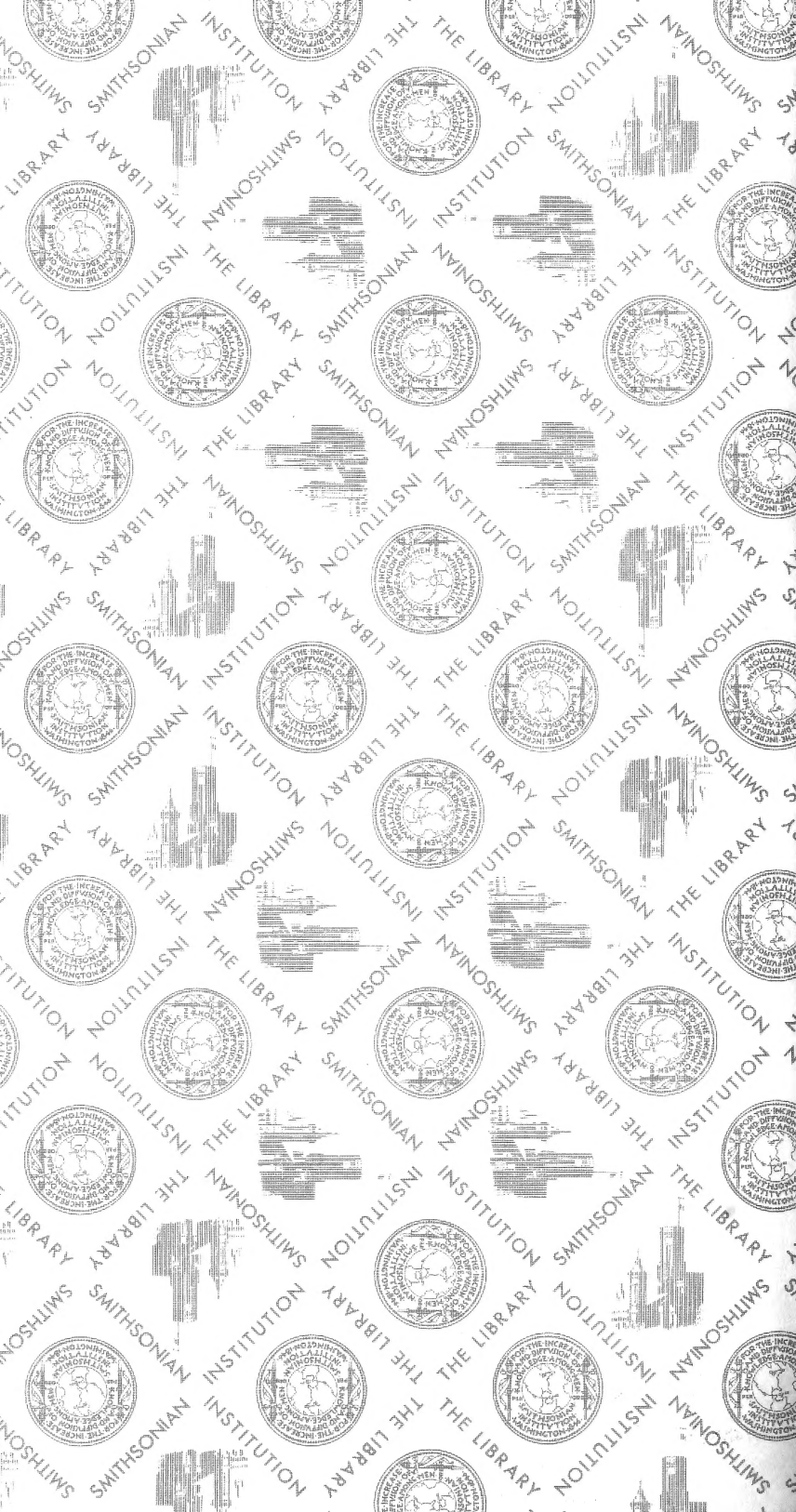












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